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Secular trends and distributional changes in the BMI and physical activity of New Zealand adults

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A thesis
submitted in partial fulfilment
of the requirements for the Degree of
Master of Parks, Recreation and Sport Management

at
Lincoln University

by
Sarah Leigh Fahey

Lincoln University
2013

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Master of Parks, Recreation and Sport Management

Secular trends and distributional changes in the BMI and physical activity of New Zealand adults

Sarah Leigh Fahey

Health is known to be inextricably related to physical activity. The world-wide trend of increasing obesity is a major problem for health professionals, however, the extent to which physical activity contributes to these obesity patterns is not fully understood. The aim of this study was to track secular trends in body mass and physical activity patterns among New Zealand adults aged 18 years and over between 1997 and 2007 to better understand changes over time and the relationship between body mass and physical activity. Data from the 1997 National Nutrition Survey, the 2002/03 New Zealand Health Survey, and the 2006/07 New Zealand Health Survey was analysed for changes in body mass and BMI over the ten year period, and weekly physical activity patterns over a 4 year period. Over the ten year period, mean weight increased by 4.8 kg (95% confidence limits CL 3.9-5.8 kg) in males and 3.7 kg (CL 2.8- 4.5 kg) in females. No substantial change in height was observed. Mean BMI increased over the same period by 1.6 kg/m^2 and 1.3 kg/m^2 for males and females respectively with an 11.7% increase in the proportion of males being classified as overweight or obese and a 7.6% increase in the proportion of females classified as overweight or obese. Between 2003 and 2007 the total weekly moderate to vigorous-intensity physical activity decreased by 39 and 25 minutes for males and females respectively. Brisk walking increased from 196 minutes in 2003 to 260 minutes in 2007 for males and 142 minutes in 2003 to 179 minutes in 2007 for females, which probably contributed to the lack of change in physical activity levels. In conclusion the increase in body mass of New Zealand adults continues unabated. At least some of this increased weight is likely to be due to a reduction in moderate and vigorous intensity physical activity witnessed.

Keywords: *Physical activity, physical inactivity, BMI, obesity.*

Acknowledgements

I would firstly like to acknowledge all of the special people in my life that have in one way or another contributed to my completion of this thesis, either knowingly or not. It has been a long process of ups and downs, however it was often the simplest of conversations or comments that would fill me with passion again to keep going and complete my dream of graduating with my Master's Degree.

Thank you to the Ministry of Health and SportNZ for producing national surveys which were made avaliable for further research. Without their approval this research would not have been possible.

Of greatest acknowledgement is to my supervisor Mike Hamlin. From start to finish your help and support throughout the whole process has made the year a lot easier. I will forever be greatfull for the time that you have given up to help me and all of your excellent knowledge and advice to improve all areas of my work.

To Roslyn Kerr my associate supervisor for your help and encouragement, your input and support got me over the finish line and to Douglas Broughton for your help with all things administration and funding wise throughout the whole process.

Thank you of course to Lincoln University. Your financial assistance throughout the Master's program has allowed me to filfull one of my research dreams, to present my research at a prestegious conference directly related to my research topic area. Also thank you to all of the Lincoln Univeristy staff and students that have given me support, advice and encouragement.

I would also like to acknowledge LUSA and Lincoln University for putting on the Postgraduate Conference. I throughly enjoyed presenting my research and meeting all of the other students from differing disciplines. I also gained some great points for my discussion section that I had not thought of and the whole event sparked greater interest in my project and research.

Of special mention, my family, Rhonda, Kevin and Maria. Thank you for all of the love and support throughout the last five years of study up to this point. Your encouragement was overwhemling and your love and support made all the difference.

Also to Charles and all of my friends, thank you for being there, an ear to vent my frustration on and someone to laugh with.

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Glossary

Physical activity - Physical activity refers to all movement produced by skeletal muscles that increases energy expenditure, whether it is incidental, occupational or recreational.

Physical inactivity - Less than 30 minutes of any physical activity in the last week.

BMI - Calculated by weight divided by height squared. It is commonly used to classify people into body size categories. The categories are intended to highlight people or populations with an increased risk of health conditions associated with increasing BMI, not to measure body fatness per se. It does not differentiate between lean and fat mass, nor does it provide information on body fat distribution. Therefore BMI is an indicator of excess weight for height.

Waist circumference - The simplest and most convenient indicator of abdominal obesity. It provides useful complementary information to BMI. Excess fat in the abdominal compartment is more metabolically active and more strongly linked to disease risk than total fat mass.

Ethnicity - A social construct of group affiliation and identity. Members of an ethnic group have one or more of the following four characteristics; they share a sense of common origins, they claim a common and distinctive history and destiny, they possess one or more dimensions of collective cultural individuality and they feel a sense of unique collective solidarity. Often self-reported and can be identified within differing ethnic groups.

Deprivation- An area based index measuring the level of deprivation for each mesh block according to income, transport (access to car), living space, home ownership, employment status, qualifications, support (sole-parent families) and access to a telephone. A linear scale is used where 1 is described as least deprived, while 5 as most deprived.

Definitions obtained from the 2002/03 & 2006/07 'A Portrait of Health' (MOHf, 2004; MOHg, 2008).

Abbreviations

BMI - Body Mass Index

NNS - National Nutrition Survey

NZHS - New Zealand Health Survey

MOH - Ministry Of Health

SPARC - Sport and Recreation New Zealand (now Sport NZ)

Who - World Health Organisation

Chapter 1
Introduction

Obesity is almost always preventable (Ofei, 2005; WHOc, 2012), but the key factors that can prevent the onset of obesity are habitually neglected. In 2008, more than 1.4 billion adults were classified as overweight, with over 200 million men and nearly 300 million women classified as obese (WHOc, 2012). Despite this, there has been a continued upward trend in weight, reflecting the growing epidemic of obesity (Cole, 2003 cited in Danubio & Sanna, 2008). Declining amounts of physical activity have contributed markedly to the increasing prevalence of obesity (Prentice & Jebb, 1995; Jebb & Moore, 1999 cited in Livingstone et al., 2003; Saris et al., 2003). However, whether these trends in weight and activity can be attributed to the whole population or a certain portion of the population is unknown. Is everyone gaining weight, or is it certain subgroups of society whose weight is changing? Answers to these questions are needed and are of increasing importance, as the real life consequences of these figures are likely to be the cause of the increased prevalence of contemporary chronic diseases within New Zealand society. Chronic diseases such as cardiovascular disease, some cancers, diabetes and hypertension (WHOc, 2012) all increase our risk of mortality and measuring variables such as physical activity and BMI are important steps in understanding this disease relationship. Through the increased prevalence of these hypokinetic diseases and the increased cost and reliance on health care funding, the health problems resulting from overweightness and inactivity then shifts from the individual to a national problem.

1.1 The research

The research project was designed to investigate the secular trends and distributional changes in the body mass index (BMI) and physical activity of New Zealand adults. Re-analysis of Ministry of Health national survey datasets was done to examine trends over time and look deeper into what groups are gaining weight, the distributional changes in weight, the changes over differing intensities of physical activity, and BMI in relation to physical inactivity.

In recent years the 1997 National Nutrition Survey, the 2002/2003 New Zealand Health Survey and the 2006/2007 New Zealand Health Survey have all been used to collect a range of data from a large population base. To date, much of the information gathered in these New Zealand wide surveys has not been analysed to its full potential. The purpose of this study is therefore to expand on what is described as 'baseline research' and compare trends over a decade of collected data.

Statistical testing, matching analysis, and distributional percentiles were carried out on the data sets from the three surveys mentioned above, to find out whether all New Zealand adults are becoming heavier and more inactive or whether the change in fatness and physical activity can be attributed to certain proportions of the population. The associations between inactivity and body mass were then investigated along with age, gender, ethnicity, location and deprivation parameters.

It is hypothesised that while the mean adult BMI is increasing and physical activity decreasing over time, these changes are not homogeneous throughout the New Zealand adult population. The goal of this research will be to further highlight the state of health and physical activity in New Zealand and to highlight problem areas from a longitudinal perspective.

1.2 Objectives

The objectives of this research are as follows;

1. To establish whether all New Zealand adults are becoming heavier and more inactive over time or whether changes in fatness and physical activity can be attributed to certain proportions of the population.

2. To determine what effect age, gender and ethnicity play in the results.

3. To determine the associations between BMI and inactivity.

Various gaps are apparent within the literature regarding the changes in physical activity and body mass of New Zealand adults over the last few decades. Limited adult research concerning where the greatest changes are occurring and whether it is everyone or just a small proportion of the population are foremost gaps. Little work has been completed to evaluate changes in body mass and physical activity of the New Zealand population over time and in particular changes in distributional patterns. This thesis will endeavour to answer some of these questions.

1.3 Thesis overview

The thesis will begin with a review of the relevant literature on physical activity and body mass in adults. The health and financial implications of obesity will then be discussed along with the current trends in BMI and activity worldwide and their combined relationship. The effects of differing variables in relation to BMI and activity will be incorporated and lastly research on the methods used and the gaps found in the current research will be described. The literature is then followed by a description of the methodology used within this study and the results found from the analysed data. Lastly the main findings of the research will be discussed and subsequent conclusions drawn.

Chapter 2

Review of the Literature

2.1 Introduction

The literature review will focus on the topic areas of obesity, BMI and physical activity/ inactivity. Within each of these areas, past research into the trends and changes occurring will be reported, incorporating the research parameters of gender, age, ethnicity, deprivation and location within each of these themes. The differing methods of analysis will then be reviewed, followed by the gaps in the current literature and why this particular research topic is being completed.

2.2 Obesity and physical activity/ inactivity

Obesity has reached epidemic proportions (Rush et al., 2003; Ofei, 2005; WHOd, 2012). Overweightness and obesity is reported as the fifth leading risk factor for deaths globally (WHOc, 2012), with reports of at least 2.8 million people dying each year from being overweight or obese (WHOd, 2012). But as Mhurchu et al. (2004) suggest, it is unclear whether the current epidemic of obesity is due primarily to population increases in food consumption, decreases in exercise, or a combination of both (Mhurchu et al., 2004). Skidmore & Yarnell, (2004) suggest that the two main preventable causes of obesity are a lack of physical activity and chronic consumption of excess calories. With excess consumption, more people are eating out and getting larger, by consuming more energy dense fat foods (Corsica & Perri, 2003). Saris et al. (2010) argue that weight increases are due to a decline in daily physical activity levels (PALs), and describe this as a major factor contributing to the current obesity epidemic affecting both developed and developing countries in the world. The emerging problem is associated with increasing morbidity and mortality and reduced psychological health (Saris et al., 2010).

Overweightness and obesity have been described as conditions in which body fat stores are charged to an extent which impairs health (Garrow, 2000 cited in Skidmore & Yarnell, 2004). Overweightness and obesity are the result of a positive energy balance, described as, a long term excess of energy intake (food and beverage consumption) over energy expenditure (basal metabolic rate and physical activity) (MOHa, 2012; Mhurchu et al., 2004). The Ministry of Health advise that although some people are more genetically susceptible to weight gain than others, the rapid increase in the prevalence of obesity in recent years has occurred too quickly to be explained by genetic changes only, and that most experts believe it is due to living in an increasingly 'obesogenic' environment. An obesogenic environment promotes over-consumption of food and drinks and limits opportunities for physical activity (MOHa, 2012).

Along with energy intake and energy expenditure, genotype and environment are also reported as determinants of body composition and as influencing the maintenance of body weight (Rush et al., 2003). Previous literature demonstrates that the imbalance of energy that results in obesity comes from societal, behavioural, genetic, hormonal and neural influences (Lustig, 2011, cited in Skidmore & Yarnell, 2004) and that the tendency for obesity is inherited, (Bray, 1998; Barch, 2000 cited in Skidmore & Yarnell, 2004) at least in part. Responsiveness to dietary intervention is also reported to be genetically pre-determined (Perusse & Bouchard, 1999 cited in Skidmore & Yarnell, 2004).

As these studies suggest, the cause of the obesity epidemic still appears to be a matter of debate. It remains unclear whether the epidemic is due to a lack of physical activity, the extra consumption of calories, or a combination of the two. This research hopes to provide greater understanding into the connections between physical activity and the growth of obesity. Through analysis of the trends and changes that are occuring in overweightness and obesity within the sample population (adult New Zealanders) and the physical activity levels of those participants, it is hoped that greater clarity into the associations between inactivity and bodymass will be found.

2.3 Health implications of obesity and physical inactivity

2.3.1 **Obesity**

Almost every research paper reviewed in this literature search identified a similar list of obesity and activity related diseases. The risks vary slightly for activity and weight related diseases. However, excess body weight was shown to be a stronger risk factor for developing chronic disease than physical inactivity (Atlantis, Lange & Wittert, 2009). But predominately a raised BMI (25 kg/m^2 and above for males and females) is reported to be a major risk factor for non-communicable diseases such as, type 2 diabetes, cardiovascular disease (mainly heart disease and stoke), some cancers including endometrial, breast and colon and musculoskeletal disorders, especially osteoarthritis (WHOc, 2012). Furthermore sleep apnoea, reproductive abnormalities (Corsica & Perri, 2003; MOHa, 2012) and gallstones are also associated with an increased body mass (Corsica & Perri, 2003).

The Ministry of Health report that the impact of this excess body weight on these diseases operates, at least in part, through its effects on insulin resistance, blood glucose, blood lipids and blood pressure changes (MOHa, 2012). The World Health Organization advises that the risk of these non-communicable diseases increases with the increase in BMI (WHOc, 2012). Although BMI cut-offs have been used to define overweightness and obesity, the risk of disease increases as BMI increases in all population groups, even those within the 'normal' range (MOHa, 2012). Mortality rates are reported to increase by 50% to 100% when BMI is equal to or greater than 30kg/m^2 as compared with BMI's in the normal range (Troiano et al., 1996 cited in Corsica & Perri, 2003). However, considerable proportions of BMI-attributable events occur well below 25 kg/m^2 (Mhurchu et al., 2004), as many more events are described within the literature to arise from the 'moderate' middle of the distribution rather than the 'high-risk' tail of high BMI. Therefore, at the population level, the most appropriate focus should be on the mean BMI, rather than on proportions of the population above arbitrary thresholds (Rose, 1985 cited in Mhurchu et al., 2004). This is one of the pivotal research points within this research paper, as mean BMI levels will be used to identify what the current mean values are, and what those mean values represent for the health of future populations. But just as importantly we must also consider the spread of data, as focussing in on the mean does not always give a good indication of the true state of affairs, particularly at the extremes of data values.

Extreme health consequences as a result of diabetes are increasingly becoming an important negative by-product of the rising obesity epidemic. Research out of New Zealand reports that the health problems that are associated with obesity, such as type 2 diabetes mellitus and coronary heart disease are more prevalent in New Zealand Maori and Pacific Island adults than Europeans (Bathgate et al., 1994; Simmons et al., 1994; Bell et al., 1996 cited in Rush et al., 2003). Diet, lifestyle and socio-economic status are regularly cited as the reason behind this finding. These ethnic differences will be explored further within this research. The following section will expand on the health risks associated with physical inactivity.

2.3.2 **Physical inactivity**

Physical inactivity is complex. Someone may be quite active, but also very inactive (sit around a lot) the rest of the time, making physical inactivity not only difficult to comprehend but also difficult to research. It is well documented that physical inactivity has a high correlation with BMI and overweightness. The research into physical activity suggests that not staying active increases the risk of chronic diseases such as; heart disease, strokes, type 2 diabetes, colon cancer, breast cancer, high blood pressure, osteoporosis and osteoarthritis (MOHb, 2012). As physical inactivity is responsible for a reported 6% of deaths worldwide (MOHb, 2012; WHOa, 2012) and identified as the fourth leading risk factor for global mortality (WHOa, 2012), more New Zealand research like the current work being presented is necessary. The findings also highlight physical inactivity as being similar to the established risk factors for non-communicable disease like smoking and obesity (Lee et al., 2012).

Research by Lee et al. (2012) suggests that if physical inactivity could be eliminated, the life expectancy of the world's population would increase by 0.68 years, and up to four years for individuals who move from an inactive to an active lifestyle. Lee et al.'s (2012) findings are consistent with research stating that the majority of health benefits (prevention and reduction of health problems and improved physical and emotional health) are reported to occur when sedentary adults become moderately active (Haapanen et al., 1996 cited in Lindstorm, Hanson & Ostergren, 2001; Jennings et al., 1986; Nelson et al., 1986; Paffenbarger et al. 1986; Leon et al., 1987; Reaven et al., 1991; Blair et al., 1992; Blair & Connelly, 1996 cited in Livingstone et al., 2003).

Regular and adequate levels of physical activity in adults has been associated with a reduction in the risk of hypertension, coronary heart disease, stroke, metabolic syndrome, type 2 diabetes, breast and colon cancer, depression and the risk of falls. Along with increased cardiorespiratory and muscular fitness, healthier body mass, improved cognitive function, and bone health (WHOa, 2012; Lee et al., 2012).

Blair, (2012) believes that evidence supports the conclusion that physical inactivity is one of the most important public health problems of the 21st century, and may even be the most important. The current research will expand on our knowledge of the activity and inactivity levels of New Zealand adults, with duration, intensity, and frequency reported. Through a greater understanding of current activity levels, future predictions of health problems can be made and subsequent planning and funding can be discussed.

2.4 Economic implications of obesity and physical inactivity

While the physical consequences of overweightness and physical inactivity have been documented, we must also consider the real costs involved with these health problems and who will be paying these costs into the future. Obesity is estimated to encompass up to 6% of total health care expenditure in some developed countries (Wolf & Colditz, 1998 cited in Swinburn, Gill, & Kumanyika, 2005) and as the epidemic progresses there will be an increasing strain on limited budgets to meet these costs if solutions are not found.

Corsica and Perri, (2003) estimated the direct economic cost of obesity worldwide to be $99.2 billion in 1995 and the indirect cost to be $47.6 billion. They further found that $33 billion is spent annually on weight-loss interventions, exercise programs, weight-control books, and diet, food and beverages

(Thomas, 1995 cited in Corsica & Perri, 2003), all of which is having little effect on the epidemic. Within New Zealand the health burden of non-communicable, preventable diseases related to obesity and inactivity continue to grow, while the budgets for such disease preventions diminish. The direct cost of obesity within New Zealand was estimated at over $100 million per year in 1997 (Swinburn et al., 1997 cited in SPARC, 2005) and by 2006 these figures were reported to be between $722 million and $849 million per year (Swinburn - MSN, 2012). It was argued in 1997 that a 10% increase in physical activity could save $55 million through reduced health expenditure, additional years of life and decreased incapacity (MOHl, 1999; SPARC, 2005). Obviously this health saving would be considerably more in 2013.

An international obesity task force looking into obesity prevention concluded that current decisions on policies and funding allocation are usually dominated by political, economic and historical forces rather than on evidence based knowledge (Swinburn, Gill & Kumanyika, 2005). Hodge, Dowse & Zimmet, (1996) conclude that the resources directed at preventing obesity and other lifestyle-related western diseases today will be repaid in the future by savings in health care costs and improved productivity. Through continued research like the one currently being presented it is hoped that the real life statistics and trend analysis create a clearer picture of the current situation, in terms of inactivity and obesity, which might guide future policy decisions.

The following sections will now discuss the trends and changes that have occurred in BMI, physical activity/ physical inactivity and the possible reasons behind such changes.

2.5 Trends and changes in BMI

Body mass values are increasing and the upper limits of those values are continually being exceeded. One of the contributing factors to these increasing trends is the changes in our energy expenditure and caloric intake. In current times, this is argued to be a 7:1 compared to a 3:1 subsistence efficiency of our prehistoric ancestors (Saris et al., 2003). The ratios were developed on the supposition that physical activity of ancestral humans averaged about 1000 kcal d^{-1} and that their caloric intake was typically about 3000 kcal d^{-1}. This meant that their subsistence efficiency was about 3:1. In contrast, Saris et al. (2003) describes that sedentary humans in contemporary affluent societies commonly consume 2100 kcal $d^{-1,}$ with expenditure as physical activity of perhaps 300 kcal d^{-1}, a subsistence efficiency of 7: 1. Saris et al. (2003) argue that re-establishing this 3:1 ratio, would halt the obesity epidemic and redirect body composition and metabolism towards that ancestral standard for which the human genome was originally selected (Saris et al., 2003), by balancing our calories in with our energy expenditure out.

Rosner et al. (1998) and Lazarius et al. (2000) cited in Turnbull, Barry, Wickens & Crane, (2004) have suggested that not everyone is gaining weight, but in fact the trend is disproportionately increased for those that are already heavy. The distributional work by Turnbull, Barry, Wickens & Crane (2004) found a significant increase in BMI for each quartile analysed, although the difference was reported to reduce at lower BMI quartiles. Albon, Hamlin and Ross, (2010) found similar distributional change with an increase of close to 20% within boys BMI in the 75th percentile from 1991 to 2003. Albon, Hamlin and Ross, (2010) also suggest a large proportion of the increases in overall BMI were probably due to the children in the 75th percentile and above BMI groups. This distributional method of analysis will be used within this study to asses body weight changes in adults over a ten year period.

Not only is body mass increasing overall but the nature of excess body weight may be changing over time to one of greater central adiposity (Elobeid et al., 2007; Walls et al., 2007 cited in Walls et al., 2011). Walls et al. (2011) found that the increases in waist circumference were more than could be attributed simply to increases in BMI, with a 4.7cm increase over the study period and BMI by 1.8kg/m^2, showing an independent increase in waist circumference over and above that for BMI. Walls et al. (2011) suggest that looking at BMI alone may underestimate the associated health burden, since evidence suggests adipose tissue deposition around the waist is the most dangerous (Janssen, Katzmarzyk & Ross, 2004; Taylor et al., 2010). These suggestions will be factored into this study, as not only will BMI be analysed for change, but similarly weight, height and importantly waist circumference will also be analysed.

Factors reported to be contributing to rising obesity rates worldwide include large-scale societal and nutritional changes that accompany economic growth, modernization, and globalization of food markets (WHO, 2003; Hawkes, 2005; Hawkes, 2006 cited in McLaren, 2007). Overweightness and obesity was once considered a problem only in high income countries, however it is also on the rise in low- and middle-income countries, particularly in urban settings (WHOc, 2012). Pacific nations, and in particular Micronesia have been listed as an area with exorbitantly high levels of excess weight among residents (McLaren, 2007), however, cultural forces influence the higher levels of body mass seen within these individuals.

Obesity rates tend to be higher for women than men (Flegal et al., 1999-2000; Mokdad et al., 2001; National Centre for Health Statistics cited in Truong & Sturm, 2005). However Truong & Sturm, (2005) report that on average women have a lower BMI than men, although they gained weight faster. The suggestion that women’s increasing participation in the workforce may have a differential effect on their weight trend relative to men may explain this (Truong & Sturm, 2005). This could also be explained by men being heavier due to increased muscle mass.

Another relevant variable is that of age. A gradual weight increase from middle age onwards has been documented (Metcalf, 2000). However, greater increases in weight in younger populations are emerging. Reports of an increase in childhood obesity is evident (WHO, 2003; Turnbull, Barry, Wickens & Crane, 2004; Onis & Blossner, 2000 cited in Ofei 2005). New Zealand research into this growing epidemic found that one in ten adolescents were obese (13%) and an additional 24% were overweight (Utter et al., 2010). With strong evidence indicating that obese children are more likely than their non-obese counterparts to grow into obese adults (Goran, 1990-1999 cited in Ofei, 2005) intervention is key, as prevention before adulthood has been described as the greatest chance of reducing the health burden of obesity (WHO, 1998; National Health and Medical Research Council, 1997; U.S. Department of Health and Human Services cited in Peeters et al., 2004).

Historically, different societies have placed differing values on bodies of different sizes. McLaren, (2007), within his Canadian research noted for men, more so than women, a larger body size is likely to be valued as a sign of physical dominance. Some ethnic groups also view obesity and body mass values differently. People of Pacific nations who did not traditionally value thinness are reported to be slowly changing with the introduction of television in some island families (McLaren, 2007). These new ideas on body image are working against traditional beliefs. Obesity is not new among pacific populations, but rather, it has long been regarded as a symbol of high social status and prosperity in the region, but not necessarily in commoners (Howard, 1986; Nauru, 1992; Langdon, 1975 cited in Hodge, Dowse & Zimmet, 1996). It has been well documented that Pacific Island people find a fuller figured body more attractive (Barrow, 1967; van Dijk, 1991 cited in Metcalf et al., 2002). This is one of the cultural forces working within smaller nations associated with New Zealand that is complicating this obesity epidemic, as historical beliefs are conflicting with health risk factors. Since many Pacific people also have residential status in New Zealand, this cultural problem becomes a New Zealand health problem. Not only Pacific adults but their children are also represented in the BMI statistics with 27% Pacific compared to 6.4% of European children found to be obese (Utter et al., 2010).

Modernization is one of the common themes portrayed throughout the existing literature as a possible contributing factor behind the trends and changes in weight, particularly within ethnic minorities. Hodge, Dowse & Zimmet, (1996) hypothesised that since World War II the rate of modernization in Pacific populations (specific to their study) has increased dramatically, bringing changes in lifestyle that have precipitated an epidemic of obesity. Historical records suggest that obesity has become much more common in pacific communities since the arrival of Europeans. Modernisation has resulted in lifestyle change leading to obesogenic ways of life, particularly in younger adults. In Samoa there was a 179% increase in obesity rates from 1987 to 1994 in men aged 25-34 years (Hodge, Dowse & Zimmet, 1996). Even with the historical cultural belief of a larger body being more attractive, the Pacific Nations have still seen a rise in obesity. The reduced obesity among older subjects found by Hodge, (1996) may reflect a slower adoption of modern diet and lifestyle behaviours compared to the younger Samoans. Since Auckland has the biggest Samoan population in the world. These problems of overweightness and obesity are likely to be higher in the Auckland area.

A positive association between BMI and socioeconomic deprivation was observed within the New Zealand research by Utter et al. (2010) in Pacific, Maori and European people. The more deprived are suggested to have greater increases in weight as the once limited food source is now in an abundance with lower prices on fatty foods (McLaren, 2007). Their income is less and as a result opportunities to buy healthier (more expensive) foods lessen. They are less likely to be involved in sports and they are more likely to be lower educated and less aware of the benefits of physical activity and healthy food alternatives.

Corsica & Perri, (2003) also report that people of the same ethnic groups but in differing locations can have twice the incidence of obesity (Corsica & Perri, 2003). Such differences are suggested to be due to the fact that some groups readily assimilate the westernised diet and lifestyle, while the more traditional groups do not. We have limited information on the impact that these increasingly modern and urban environments are having on more traditional Island populations.

Tracking the body mass changes of these ethnic minorities over time will be important for the future. Greater analysis of subgroups within this study, particularly ethnicity and deprivation will provide greater insights into the New Zealand trends in BMI and obesity. Corsica & Perri, (2003) suggest that reversing the epidemic of obesity will require a major public health initiative aimed at identifying and implementing effective behavioural, educational, and environmental strategies for the prevention and control of obesity.

The literature review will now focus on the trends and changes that have occurred within physical activity/ inactivity which is closely linked to obesity via energy balance.

2.6 Trends and changes in physical activity/ Inactivity

Approximately 3.2 million deaths worldwide each year are attributable to insufficient physical activity (WHOb, 2012). WHO describes that globally, around 31% of adults aged 15 years and over were insufficiently active in 2008 (men 28% and women 34%) (WHOb, 2012). Physical inactivity is now recognized as one of the most important modifiable risk factors, causing the rising global burden of chronic disease (Bull et al., 2004; WHO, 2005; Bauman, 2004; WHO, 2004 cited in Guthold et al., 2008). Despite the known health benefits of moderate exercise, fewer than 40% of adults in the western world currently participate in regular physical activity (Seefeldt, Malina & Clark, 2002 cited in Plotnikoff et al. 2004). Others similarly report this figure to be more than 60% of adults in the western world currently do not exercise on a regular basis and 25% of adults are classified as sedentary (US Department of Health and Human Services, 2001 cited in Skidmore & Yarnell, 2004; Katzmarzyk, Gladhill & Shepard, 2000; National Centre for Health Statistics, 1992; 1999; and Stephens & Craig, 1989 cited in Seefeldt, Malina & Clark, 2002).

The question is why are physical activity levels decreasing? Physical activity behaviour is influenced by a myriad of factors including demographics, biological, psychological, behavioural, social and/ or cultural and physical environments (Bauman et al., 1998; Sallis & Owen, 1999; Trost et al., 2002 cited in Plotnikoff, 2004). Socio-economic factors, community design and bodyweight may also have an influence on physical activity patterns (Bryan & Walsh, 2004; Craig et al., 2002 cited in Bryan et al., 2006). Through a greater understanding of our physical activity behaviour and the changing nature of how individual's execute their physical activity, it may be possible to provide solutions to enhance physically active opportunities.

Lindstorm et al. (2001) suggest that a number of barriers to physical activity are evident in society today. Internal barriers such as a lack of motivation or lack of leisure time are more common in higher socioeconomic groups, while external barriers such as lack of money, lack of transport or illness/disability are more common in lower socioeconomic groups (Chin et al., 1999 cited in Lindstorm, Hanson & Ostergren, 2001).

Adult physical activity is reported to be mainly achieved through occupational activity, active transport, caregiving responsibilities and leisure pursuits (Livingstone et al., 2003). Banwell et al. (2008) suggests that time pressure leaves both adults and children with a sense that they cannot afford the time required for active transport to work and school, diminishing the opportunities for incidental physical activity. Other suggested reasons for these trends in activity include the fact that more people are engaged in sedentary work than before, spend more time in traffic queues and in front of the television and computer monitors in their spare time, and the time for leisure pursuits has declined (Grantmakers of Health, 2001 cited in Skidmore & Yarnell, 2004). It is suggested that exposure to work-related physical inactivity may have a greater effect on developing chronic disease than a lack of recreational activity (Weller & Corey, 1998 cited in Atlantis, Lange & Wittert, 2009). Emerging research suggests that greater workplace initiatives to improve physical activity are becoming more apparent.

The changing work week has manufactured its way into our lives, often decreasing opportunities for team sports and individual pursuits. Questions surrounding a 'slowing of life' (doing less to get more done) and reduced work hours, less technological gadgets and a general de-modernization of life may be the best option in order to reverse these negative changes in activity, but few would consider these drastic changes. Within the last century, major changes in lifestyles have had profound impacts on patterns of energy expenditure and physical activity in affluent countries. Increased mechanization in the workplace is said to have markedly reduced the need for moderate and high intensity activity to the extent that >80% of men and >90% of women are now engaged in sedentary occupations (Livingstone et al., 2003). Also at home, the energy cost of housework has reduced and television viewing and related low-activity pursuits now monopolize much of the available leisure time of a substantial proportion of the population (Livingstone et al., 2003). The World Health Organisation also suggests that increased urbanization has resulted in several environmental factors which may discourage participation in physical activity such as: violence, high-density traffic, low air quality, pollution, and a lack of parks, sidewalks and sports/recreation facilities and opportunities (WHOb, 2012).

Within the New Zealand context, a reported 52.1%, or only half of New Zealand adults are meeting the physical activity guidelines of at least 30 minutes of physical activity on five or more days of the week and 9.9% or one in ten adults are inactive, not completing even 30 minutes of activity per week (MOHd, 2012). No significant changes have been reported to have occurred during the last few years from 2002/03 and 2006/07 (MOHd, 2012). The Sport New Zealand study in 2007/2008 entitled the Active New Zealand Survey, found similar levels of adult physical activity with 48.2% of New Zealanders being physically active on at least five days out of seven and 12.7% complete less than 30 minutes of physical activity over seven days (MOHd, 2012). However, little is known about the trends in physical activity over time or physical activity changes within subgroups of the population. This study hopes to uncover these changes and relate these to changes in body weight.

Past research suggests that physical activity levels are not only decreasing overall but are changing in terms of intensity from vigorous intensity to more passive pursuits. The study by Sinclair, Hamlin &

Steel, (2005) found that within first year university students, significant declines in the time spent undertaking vigorous and moderate activity were evident. While the higher intensities of physical activity are low, more people are reported to be engaging in lower intensity activity such as walking (Azevedo et al., 2007). The resulting consequences of these changes suggest that less energy is being expended and therefore BMI increases, if caloric intake is not changed.

Lifestyle factors clearly influence our activity levels, along with demographic variables such as gender. Men and women have different levels of physical activity and the variables associated with activity levels are not consistent across the genders (Azevedo et al., 2007). One reason for this difference is argued to be that the reasons for undertaking physical activity are different among men and women. Men score physical activity highest for enjoyment, then for health and lastly medical advice, while women reported physical activity for health, significantly lower for enjoyment and close behind for medical advice (Azevedo et al., 2007). Azevedo et al. (2007) also found that men perform more activities in groups while women practice more individualized pursuits. The elevated rates for male physical activity may therefore be a result of social pressure to excel and perform at greater intensities and motivation around others, as opposed to the individual activities that females carry out by themselves.

Regardless of the guidelines used, globally, males are more active than females (Azevedo et al., 2007; Bryan et al., 2006; Livingstone et al., 2003) and the levels of moderate and vigorous-intensity physical activities are more frequent among men (Azevedo et al., 2007; Mummery et al., 2007). Men were reported to do 50% less vigorous activity over the age of 36 however, so high intensity in younger years is displaced in favour of less physically demanding recreational activity in older age. Women are reported to be more stable over time as they engage in less vigorous activity in the first place (Livingstone et al., 2003). Men are twice as active in occupational and leisure time activities, while women are three times more active in household pursuits. Plotnikoff et al. (2004) found that women engaged in paid sedentary work were more likely to be inactive in comparison to men who reported doing the same job. However the downward shift in occupational activity in men with increasing age was not compensated for by increased leisure or household activity, and indeed leisure activities declined further (Livingstone et al., 2003).

As mentioned above, age, also contributes to physical activity trends and changes. It has been well documented that activity levels decline with increasing age (Livingstone et al., 2003; Bryan et al., 2006) and that age inversely relates to physical activity participation (Trost et al., 2002 cited in Plotnikoff et al., 2004). The results from the research by Guthold et al. (2008) found that physical inactivity increased with increasing age, especially from the age of 50 upwards (Guthold et al., 2008).

Mummery et al. (2007) also found a significant association between age group and inactivity, with members of the 80 years and over group being significantly more likely to be inactive than their younger counterparts.

Although the trends indicate improvements, over 30% of older adults $\geq$70 years are inactive, and are at increased risk for disability, loss of muscle mass, flexibility, and balance and suffer more serious consequences from falling (Carlson et al., 1999 cited in Kruger, Ham & Kohl III, 2005). Physical functioning, disease and illness all negatively impact one's ability to perform physical activity with age. Livingstone et al. (2003) conclude that biological, psychological and sociological factors interact with physical activity over the life span, and to avoid solely generalising about age trends. As our population ages and our subsequent activity levels drop, greater research on the effects of age and physical activity will be warranted.

Along with gender and age, ethnicity has been reported within the literature as another major factor associated with the changing trends within physical activity. Bryan et al. (2006) found that the prevalence of leisure-time physical activity is lower in the majority of ethnic minority groups living in Canada. In the United States ethnic minorities engage in less leisure time physical activity than non-Hispanic whites (US Dept. of Health and Human Services, 1996; Crespo et al. 1996; Yeager, Macera & Merritt, 1993 cited in Crespo et al., 2000). Therefore physical inactivity is more prevalent among racial and ethnic minorities than among Caucasians (Crespo et al., 2000). African Americans and Mexican American men and women both reported higher prevalence of physical inactivity than their Caucasian counterparts across almost every variable (Crespo et al, 2000).

Similarly, in Canada, South Asian men and women were found to be among the least active ethnic groups. This is consistent with reports from the United Kingdom which have shown that physical activity is lower in all South Asian groups compared to the general population, especially among South Asian women and older people (Fischbacher, Hunt & Alexander, 2004 cited in Bryan et al., 2006). This is also true for Asian New Zealanders (Kolt et al., 2007). The one exception to these findings is within indigenous New Zealand Maori. As Ross & Hamlin, (2007) found Maori are at least as active as European New Zealanders. However, Pacific and Asian New Zealanders have levels of activity similar to ethnic minorities in other countries. Trend information is essential for future analysis of this phenomenon which will help drive change in this area. For New Zealand, with an ethnically diverse nation and high immigration rates coupled with lower levels of reported activity for ethnic minorities (Asian participants particularly) further research is vital.

Geographical location is also reported to have an influence on our physical activity. Rural participants have been found to be more active, with the effects of modernization in urban areas clearly evident in rural-urban comparisons and migrant studies. Such studies consistently show reduced levels of physical activity in urban versus rural subjects (Hodgkin, Hamlin, Ross & Peters, 2010) and migration from a rural area to a city has been shown to increase sedentary behaviour (Torun et al., 2002 cited in Guthold et al., 2008). Both men and women living in urban areas were more likely to be inactive compared to those living in rural areas (Guthold et al., 2008). As technology prevails and access to mechanisation creates less incidental activity and manual labour, it is becoming apparent especially within Pacific participants, that a historically physically active lifestyle is being replaced by a more sedentary one.

Lastly, deprivation plays a contributing role in the trends and changes within physical activity. However, the literature is contradictory. On the one hand deprivation literature shows that people living in mainly low and middle income countries were more likely to be inactive (Guthold et al., 2008). Strong associations between low socioeconomic status and low levels of leisure-time physical activity and increased physical inactivity have been reported (Lindstorm, Hanson & Ostergren, 2001, Azevedo et al., 2007). Similarly, it has been reported that activity levels are consistently higher in those with a higher education and income (Livingstone et al., 2003).

On the other hand reports in the same area found that the lower the socioeconomic level the lower the rate of inactivity (Azevedo et al., 2007). For example, persons with incomes over $50,000 were found to be more inactive than those at $35,000- $49,000. It is suggested that perhaps the time spent generating the additional income may compete with the time available for physical activity (Crespo et al., 2000). This data is believed to be due to the considerable amount of activities that are performed during work, commuting and household chores, for people with a very low income (Azevedo et al., 2007). The levels of physical activity for the least and the most deprived will be investigated within this study, to try and identify trends and changes in this area.

Physical activity interventions aimed at improving physical activity uptake are unlikely to be productive if the associated research into where to intervene and to be most effective, does not occur. It is hoped that through greater research like this study, a worldwide analysis of each countries trends in weight, activity and inactivity occur, in order to ascertain where the greatest need is. Limited New Zealand research into physical activity found that individuals who were female, older, overweight or obese, have a postgraduate qualification or have a chronic condition were less likely to be sufficiently active(Phongsavan, McLean & Bauman, 2006). By contrast, individuals who were single, received a trade-related education or above, Maori or reported a high income (NZ

$70,001+) or had access to recreation facilities were more likely to be sufficiently active (Phongsavan, McLean & Bauman, 2006).

While many suggestions are postulated to combat the trends and changes occurring in physical activity, clearly not enough is being done to target those subgroups emerging as the problem areas, such as: females, older adults, ethnic minorities, urban dwellers and those in the most deprived areas of society. This research will investigate all of these variables to determine the extent of the changes within the differing subgroups in terms of their physical activity patterns. This type of investigation is significantly lacking within New Zealand literature and through greater understanding of physical activity, hopefully greater understanding of obesity may be gained.

The following section will now move into greater detail surrounding past and current research into the link between the decreasing levels of physical activity and its effect on increasing BMI values.

2.7 Effects of decreasing physical activity on increasing BMI

Correlations of physical activity with BMI or body fat that have been reported in population studies are typically low (Kromhout, Saris & Horst, 1988 cited in Ball et al., 2001). The greatest limitation of this type of research is whether cause and effect is solely responsible for the association, or whether other confounding variables are likely. As Fox and Hillsdon, (2006) note, we still know little about the effectiveness of increasing activity on obesity prevention. Ball et al. (2001) suggest that there is only weak evidence that physical activity is a determinant of obesity.

Past research indicates a secular decline in overall physical activity that has occurred at the same time, or possibly before, the increase in obesity (Wareham, van Sluijs & Ekelund, 2005). Physical inactivity is reported to associate cross-sectionally with overweightness and obesity and longitudinally with weight gain (Foreyt et al., 1995 & Williamson et al., 1993 cited in Ball, Crawford & Owen, 2000). Time trends in obesity and overweightness with sedentary leisure-time physical activity status over the years of 1986 to 1994 (through the use of public health surveys) has shown both the proportions of people classed as overweight and obese increased among men and women and the proportion classified as sedentary increased. Increases in those classified as sedentary went from 14.7% to 18.1% for males and 19.4% to 26.7% for females. Crucially, the proportion of physically inactive persons increased with increasing BMI (Lindstrom, Isacsson & Merlo, 2003). Mummery et al. (2007) concluded that individuals who were overweight were significantly more likely to be inactive than their healthy-weight counterparts.

Sedentary activity may be both a cause and a consequence of weight gain (Livingstone et al., 2003), as activity levels are inversely associated with adiposity (Livingstone et al., 2003) and overweight subjects tend to be physically inactive in leisure time (Burke, Savage & Manolio, 1992, Gutierrez-Fisac, Regidor &Rodriguea, 1996, Martinez-Gonzalez et al., 1999 cited in Lahti-Koski et al., 2002). High baseline levels of BMI are reported to predict future low levels of physical activity (Petersen et al., 2004 cited in Wareham, van Sluijs & Ekelund, 2005). Alternatively lower body weights and lower BMI's are associated with higher levels of self-reported physical activity (Corsica & Perri, 2003).

While physical activity may affect body weight, it is also suggested that it is likely that body weight impacts on physical activity (Corsica & Perri, 2003; Hohepa, Schofield & Kolt, 2004; Kolt et al., 2007), via increased discomfort associated with higher body weight, including higher levels of breathlessness and sweating, and general difficulty in negotiating body movement (Corsica & Perri, 2003). Research by Ball, Crawford and Owen, (2000) found that 22.6% of obese respondents reported that being 'too fat' was a barrier to increased physical activity, particularly in women (6.2%), compared to men (2.2%).

A number of variables complicate our understanding of the links between weight and activity. Saris et. al. (2003) argues that daily energy expenditure declined steadily during the 20th century and the trend only accelerated in the economic expansion after World War II. It is argued that this was caused by an 'engineering of physical activity out of daily life' via increasing mechanization at work, in the home and during leisure time, along with urbanisation (Saris et al., 2003). The storing of excess calories as fat during the telecommunications and computer revolutions in the 1980's saw substantial numbers unable to regulate their energy balance, leading to the increasing prevalence of obesity (Saris et al., 2003). Unhealthy lifestyles including poor dietary habits and inadequate exercise were a notorious by-product of urbanization (Ko, Tang, & Chan, 2010).

Livingstone et al. (2003) suggested that inactivity tends to cluster with other health behaviours such as less healthy dietary practices (Lytle et al., 1995, Simoes et al., 1989 cited in Livingstone et al., 2003), cigarette smoking and alcohol use (Dannenberg et al., 1989, Raitakari et al., 1994, Lytle et al., 1995 cited in Livingstone et al., 2003) which may have adverse effects on both the quantity and distribution of body fat (Livingstone et al., 2003).

While obesity has a higher prevalence in urban as opposed to rural areas, the replacement of local food staples with imported processed foods and the reduction in physical activity associated with increasing mechanization and the cash economy are implicated in this trend (Hodge, Dowse & Zimmet, 1996). In Western Samoa and Papua New Guinea physical inactivity is independently associated with obesity, at least in men (Hodge et al., 1994; Hodge et al., 1995 cited in Hodge, Dowse & Zimmet, 1996) as modernisation has reduced occupational energy expenditure and contributed to obesity in pacific nations (Hodge, Dowse & Zimmet, 1996).

In both men and women the strongest upward trend in mean BMI over time occurred in the group with the lowest level of leisure-time physical activity (Lahti-Koski et al., 2002). Despite occupational differences on the relationship between activity and weight, men and women are also engaged in different types of activity, noting women are more likely to be active at lower intensities than males. This may affect body composition and or fitness and energy intake. Also differing biological factors may play a role in determining the strength of the relationship between physical activity and weight in men and women (Ball, 2003).

Perhaps the fact that men tend to over-report in physical activity questionnaires, may be a result of social pressure, more so for men than women. This may explain why women have higher associations with lower activity and higher BMI (Ball, 2003). While this research paper may be subject to reporting bias like those mentioned above, a greater understanding of this intricate relationship between weight and activity will be beneficial regardless.

In 1995, the US centre for disease control and prevention and the American College of Sports Medicine published the public health recommendations for physical activity. The principle recommendation for adults was to accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all days of the week. This was confirmed in the US Surgeon General's report and United States National Institutes of Health consensus report (Pate et al., 1995; US Department of health and human services, 1996; US National institutes of Health, 1996 cited in Saris et al., 2006). The current physical activity guideline for adults of 30 minutes of moderate intensity physical activity daily, preferably on all days of the week, is of importance for limiting health risks for a number of chronic diseases including coronary heart disease and diabetes (Saris et al., 2003).

However, for preventing weight gain or regain this guideline is stated to likely be insufficient for many individuals in the current environment (Saris et al., 2003). The prevention of weight regain in formerly obese individuals requires 60-90 minutes of moderate intensity activity or lesser amounts of vigorous intensity activity and moderate intensity activity of approximately 45 to 60 minutes per day (Saris et al., 2003). Past guideline recommendations for physical activity were based on the desire to improve overall cardiorespiratory fitness and general health and have not been based on optimal physical activity levels to produce a weight loss or to prevent general weight gain or regain following a loss (Saris et al., 2003). Continued research of this nature into universal guidelines and the limits that may need to be adjusted within this obesity epidemic are imperative for greater understanding of weight and inactivity trends.

To summarise, the health implications of obesity and inactivity are comprehensive, with a range of internal and external factors influencing negative trends across the two variables. The trend of increasing weight and decreasing physical activity is evident throughout the literature as changing environments are producing conditions conducive of weight gain and inactive lifestyles. Modernization, urbanisation and technological advances within our work and home lives has led to poor dietary practices, increasing caloric consumption, more sedentary occupations and more passive leisure-time activities. All of these factors combined have resulted in decreasing physical activity and increasing body weight.

2.8 Surveying

Well designed and validated questionnaires are described as the most useful method for assessing patterns, frequency, type and context of physical activity (Livingstone et al., 2003). For this reason they are useful at collecting baseline information on individual activity. Questionnaires are argued to give a good indication of different types of activity, but that they do not have a direct relationship to the energy costs of activity for any one individual (Kriska et al., 1990, Pate et al., 1996, Going et al., 1999 cited in Rush et al., 2003).

Although questionnaires are easy to use and time efficient they can also produce inconsistent results due to reporting bias. Self-reporting of physical activity is one of the first indicators to be criticised especially in terms of favourable recall (Booth et al., 1996 cited in Ball et al., 2001; Mummery et al., 2007). Many report of the overestimation of physical activity when the International Physical Activity Questionnaire (IPAQ) is used (Hallal et al., 2003; Ekelund et al., 2006; Rzewnicki et al., 2003 cited in Guthold et al., 2008) and underestimation of inactivity (Guthold et al., 2008).

Methods for assessing body mass values commonly use BMI as an index of analysis. BMI has been widely used because it is easy to calculate, however it can be a noisy measure of fatness as it does not distinguish fat from muscle, bone and other lean body mass (Yusuf et al., 2005; Kragelund & Omland, 2005; Gallagher et al., 1996; Smalley et al., 1990; Garn et al., 1986 cited in Burkhauser, Cawley & Schmeiser, 2009). It has been reported that BMI overestimates fatness among those who are muscular (U.S. Department of Health and Human Services, 2001, Prentice & Jebb, 2001 cited in Burkhauser, Cawley & Schmeiser, 2009). This often causes inconsistencies particularly in elite athletes who are often classified as overweight as a result of their large muscle mass for sport. BMI appears within this study as it is easily measured, commonly recognised and comparisons between groups are straightforward to calculate. While BMI may be inaccurate for an individual, it correlates well with body fatness in large cohorts and as it is easy to measure, it is ideal for large scale population studies such as this one, along with waist girth.

The IPAQ and self-reporting of physical activity along with BMI are two of the more commonly used methods of data collection within New Zealand. While a large population base can be collected relatively quickly and easily (compared to other physical activity methods and body mass measures) as described above these methods can also be somewhat unreliable due to bias in the self-reporting. In my opinion while the data is useful for large scale estimates of activity and body mass of a sample population, in order for more accurate and honest reporting of an increasing epidemic more rigorous testing of such measures is warranted.

2.9 Gaps in the current literature

Almost all of the New Zealand research into BMI and physical activity has been based on children (Utter et al., 2010; Goulding et al., 2007; Hohepa, Schofield, Kolt et al., 2004; Hodgkin, Hamlin, Ross, Peters, 2010; Turnbull, Barry, Wickens & Crane, 2004; Rush et al., 2003; Albon, Hamlin & Ross, 2010) and relatively little is known about such changes in adult New Zealanders. The research conducted by larger research bodies such as the Ministry of Health and Sport NZ focus on specific areas for knowledge and intervention. However, never before has full analysis of the data or long term comparisons of change been conducted. Through the development of greater comparability of public surveys within New Zealand, by way of similar survey questioning, long term comparisons can be made.

More accurate research is needed in relation to BMI and activity. Greater accuracy in terms of study design, and reliability and validity to allow for more accurate conclusions to be drawn within this complicated relationship. This relationship is one of the most pivotal within the developed and developing worlds and will become increasingly important as inactivity and body weight increases.

Research into the physical activity patterns and BMI changes within ethnic minorities is limited, particularly within New Zealand. Greater understanding of where and why deviations are emerging may provide essential information.

With aging populations and an increased awareness of the effects of age on weight and activity, research into how targeted intervention could increase activity and maintain weight in older participants may be beneficial. This research will aid in assessing problem areas within our current and future generations to try to curb negative weight and activity trends. It appears that diet along with social and environmental lifestyle factors may be negatively affecting these populations, as mass media and technology reduce their ability to overcome these trends. Therefore I hope this research will help to direct targeted intervention, inform policy and create change for our future leaders in the area of physical activity.

Lastly gaps surrounding the true extent of deprivation and the impact of geographical location and the economic wealth of the individual on your chance of being overweight and inactive needs further investigation. For example, are the most deprived in areas such as South Auckland gaining the most weight and living inactive lives, or is it the wealthiest of people in the inner cities who are living the unhealthiest lives.

2.10 Why this research topic?

As a result of obesity becoming one of the greatest problems facing contemporary society and inactivity on the rise, this research topic arose out of a lack of current research into the effect of this epidemic. Through this research, hopefully greater awareness of the state of affairs can be achieved and therefore change generated. Change not only by the powers that control our societies, but change for families and individuals affected by these worsening trends and negative lifestyle choices. Monitoring the secular trend in obesity will be crucial for public health policy and allocation of resources. Such information will enable decision makers to have a clearer understanding of where targeted intervention is needed.

The research is representative, broad, and uses a range of methods to indicate recent levels of activity and body mass, and analyse the magnitude of changes within those parameters. This further analysis of change over time was one of the motivating factors for undertaking this research. While past research has produced levels of weight and activity at separate time points, little had been done to look at those changes over the long term.

The nature of this research topic was also created out of the need for distributional comparisons to be drawn and a greater understanding of whether all proportions of society are changing in terms of their body weight, or whether body weight gains are only occurring in a selected part of the population. Being able to asses distributional variations over a ten year period will enhance our understanding of this changing trend. These research objectives are being conducted with the hope that the results will lead to improved New Zealand health outcomes, not only for current generations, but for generations to come. It is anticipated that targeted interventions can be created, and beneficial changes made to New Zealand's poor health statistics.

Chapter 3

Methodology

The methodology employed within this study was primarily conducted by the Ministry of Health in terms of the survey design, the subjects chosen, the data collected, the questions asked and the tools used for measurement of those questions. The current study then uses the original data collected by the Ministry of Health and completes re-analysis of that data.

The flowing section will begin with information on the methods used when the data was originally obtained by the Ministry of Health and detailed analysis of the procedures used and the information that was gathered. This will be followed by an in-depth look at the particular methods of analysis that I used on that collected data.

3.1 Background Information MOH Surveys

The Ministry of Health produce national surveys for many reasons, but probably the most important reason is to improve the health and participation outcomes for New Zealand. One aspect of these surveys was to draw the attention of users and researchers to the survey and encourage them to undertake or commission more detailed analysis (MOHf, 2004). The Ministry of Health state that although this information is of great relevance for policy and planning, the report cannot do justice to the richness of information potentially available from the survey. Rather, it is intended to encourage users and researchers to undertake or commission their own more detailed analysis once the confidentialised dataset is available (MOHf, 2004; MOHg, 2008). Through surveys, the Ministry of Health hope to address societal and systemic outcomes of better health, reduced inequalities, and equity and access (MOHf, 2004).

For the use of this study a wide range of surveys was analysed to gain the greatest datasets for comparison over a selected time period. The 1997 National Nutrition Survey (NNS), the 2002/2003 New Zealand Health Survey (NZHS) and the 2006/2007 New Zealand Health Survey (NZHS) were finally decided on as the questions either matched directly or were very similar and the physical activity measures were the same. The 1996/97 NZHS did not have height, weight, waist circumference or appropriate physical activity questions so was not able to be used. The 1997 National Nutrition Survey is however linked to 1996/97 NZHS with similar measures taken and questions asked to that of the NZHS.

3.2 The subjects

Subjects within the three surveys included all people aged 15 years and over who were usually residents within permanent private dwellings interviewed by the Ministry of Health. The 1997 survey had 4636 respondents, with a 50.1% response rate. The 2002/2003 survey had 12,929 respondents and a 72% response rate. The 2006/2007 survey had 12, 488 respondents and a 67.9% response rate (MOHe, 2009).

The data for all females who indicated that they were pregnant was not used for the purposes of this study. The main reason was that their activity levels may be significantly different than if they were not pregnant and more importantly, it is not an accurate measure of the individual's weight, BMI and waist circumference.

The actual demographic breakdown of the participants within each survey and over the combined surveys will be discussed later within the results in Table 1. Even proportions for age, deprivation and location were collected, although gender and ethnicity have varying inconsistencies compared to the general New Zealand population at the time of data collection, as chosen by the Ministry of Health.

A key objective noted of the 2002/2003 NZHS and the 2006/2007 NZHS was to improve the quality of ethnic estimates. Maori, Pacific and Asian ethnic groups were therefore over-sampled to provide more reliable results. The Ministry of Health reported that this resulted in more of these ethnic groups participating than in previous surveys. Also, Chatham and Pitt Islanders were over-sampled (MOHf, 2004; MOHg, 2008). Although these ethnic minorities were oversampled within the current study, by looking at the data as subgroups the problem of skewed results towards these oversampled minorities is partially averted. Furthermore, the greater the information that can be collected and analysed on these ethnic minorities in terms of body mass and physical activity the better, as there is a distinct lack of information on these minority groups.

3.3 The survey

Further information into the surveys used is available on the Ministry of Health website. The 2002/03 and the 2006/07 'Health Survey Questionnaire', also the 1997, 2002/03 and 2006/07 'National Confidentialised Unit Record File (CURF) Data Dictionary' and the 2006/07 content guide provided the required information in order to interpret and organise all three of the datasets into one complete comparable data file (MOHj, 2005; MOHk, 2005; MOHl, (N.d.); MOHm, 2008; MOHn, 2006; MOHo (N.d.)). This file was created by lining the three datasets up beneath each other and matching the questions asked within the differing surveys horizontally in Excel.

The relevant physical activity and body mass variables were selected from the three surveys and compiled into a new Microsoft Excel dataset containing all information. Anyone under the age of 18 years old was excluded from the sample. Those that were pregnant were not included and anyone with missing data or with inputting errors was also removed.

The surveys were said to have taken on average 60 minutes to complete. The surveys were a face-to-face computer-assisted survey interview followed by a short health measurement section. The surveys had four health and one demographic module (MOHf, 2004; MOHg, 2008).

Participants were asked to self-select gender, with a choice of male or female. Age was completed by asking the year born and then working out their age and putting them into one of seven pre-determined age groups. Ethnicity was broken down into five categories of Maori, Pacific, Asian, Other and European. Deprivation was determined from the list of criteria - income, transport (access to car), living space, home ownership, employment status, qualifications, support (sole parent families) and access to a telephone. A linear quintile scale was used, adapted from the NZDep2001 where 1 was described as least deprived, while 5 was the most deprived. Location was determined by urban being areas with populations over 999 people and above and rural being less than 999 people (MOHf, 2004; MOHg, 2008).

The demographic and socio-demographic questions were taken from the 2001 Census and or the Household Labour Force Survey to ensure comparability with other major surveys. The physical activity questions were comprised from the New Zealand physical activity questionnaire short form, a local adaption of the international physical activity questionnaire that the Ministry of Health had developed in partnership with Sport and Recreation New Zealand and Statistics New Zealand which was subsequently validated by the University of Auckland (University of Auckland, 2003). Refer to Appendix A for the questions.

Physical activity was established from a list of questions. The questions were divided into the areas of brisk walking, moderate intensity activity and vigorous intensity activity; Brisk walking was asked as 'During the last 7 days on how many days did you walk at a brisk pace – a pace at which you are breathing harder than normal? This includes walking to work or school, while travelling from place to place, at home, and at activities that you solely did for recreation, sport, exercise or leisure. Think only about brisk walking done for at least ten minutes at a time.'

Moderate intensity physical activity was asked as 'During the last 7 days on how many days did you do moderate intensity activities like carrying light loads, bicycling at a regular pace, doubles tennis or other activities like those listed on card 135? Do not include walking of any kind.'

Vigorous intensity physical activity was asked as 'During the last 7 days on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, fast bicycling, or other activities like those shown on card 137.'

The questions of 'thinking only about (brisk walking, moderate or vigorous physical activity) done for at least 10 minutes at a time', on how many days per week and how much time did you typically spend on (brisk walking, moderate or vigorous physical activity) on each of those days, followed each intensity.

Total physical activity for this analysis consisted of; Physical activity = brisk walking + moderate activity + (vigorous activity x 2). This means that all brisk walking activity minutes over the seven measured days, all moderate intensity activity minutes over the seven measured days and all vigorous intensity activity minutes over the seven measure days (multiplied by two) were added together to give an overall physical activity measure. Physical inactivity was established as undertaking less than 30 minutes of physical activity over the previous seven day period.

For establishment of meeting physical activity guidelines, the survey question 'days active out of seven' was used and if the participant stated that they had done at least 30 minutes of any activity on five or more days out of seven, they therefore meet the New Zealand physical activity guidelines.

The body mass questions and measures were completed last. Two measurements were taken and if a measured deviance of 1 per cent or more was detected a third measurement was taken. See data collection methods. Also refer to Appendix B.

The BMI classifications from the height and weight survey questions were from the WHO worldwide principle cut-offs points of;

Underweight - $<18.5\text{kg/m}^2$

Normal weight - $18.5 – 24.99\text{kg/m}^2$

Overweight - $25 – 29.99\text{kg/m}^2$

Obesity - $\geq 30\text{kg/m}^2$

Waist circumference cut-off points listed below were measured by their risk on health:

Low risk –men <94 cm   women <80cm

Increased risk- men ≥94- <102cm   women ≥80-<88cm

Substantially increased risk – men ≥102cm   women ≥88cm

3.4 Recruitment

The sample frame was an area-based frame. Mesh blocks were the primary sampling units and geographical clusters were used. Kish grids were used for respondent selection for interviewing of one person from those eligible in the household (MOHf, 2004; MOHg, 2008).

The surveys were voluntary. Adults who were selected were told about the survey and given an information brochure. If they agreed to take part, they were asked to sign a consent form (MOHf, 2004; MOHg, 2008)

3.5 Data collection

The collection mode that was chosen was face-to-face interviewing using trained interviewers. The interviewers were provided with a complete questionnaire survey for each chosen participant. When collecting the body size variables anthropometry was the chosen method.

The three common anthropometric measures were height, weight and waist circumference. Measurements were to be made on a hard surface. The first step was for the interviewer to tell the respondent what they were going to do and then ask the respondent to remove their shoes and any heavy outer clothing, so measurements could be made in light clothing. For height a SECA 214 portable stadiometer was used and measurement was taken while the participant was taking a breath in. Once recorded the participant stepped off the meter and the interviewer entered the reading into the computer.

For weight SECA 770 or Tanita HD-351 weighting scales were used. The respondent stood on the scale until a reading appeared and then stood back off while the interviewer recorded the figure. The scales only go to 200 kilograms and anyone over this is recorded as 200+ kg.

Waist girth was measured using a Lufkin W606PM anthropometric measuring tape and a cross-handed technique around the abdomen at the narrowest point. The respondent was asked to breathe normally and measurement was taken and recorded by the researcher after the respondent had breathed out.

Researchers then repeated all of the height, weight and waist methods in the same order and using the same techniques. If the computer then prompted a third reading of any of the measurements that was then completed. This is done to limit error and correct possible miscalculation. All of this information was reported within (MOHh, 2008; MOHi, 2008). More information is available in Appendix B.

3.6 Confidentiality

Any information collected in the survey that could be used to identify individuals has been treated as confidential. Names and addresses of people and households collected in the survey have not been stored with their responses. No information was released in a way that would enable an individual or a household to be identified and no contact, geographical or provincial details included.

The Ministry of Heath have given the consent to use the micro data. They have not given any further information on whether participants gave consent on further use of the data. However, an acceptable six year time period since the data was collected and the manner in which the data was collected, alludes to the fact that the data was going to be used in the future.

Following ethical approval from the Lincoln University Human Ethics Committee, the three survey datasets were analysed retrospectively.

3.7 Statistical analysis

With the data stripped of any identifiable material and all non-applicable participants excluded, the compiled dataset was then ready for analysis.

Initially all variables were analysed using Proc Mixed in the Statistical Analysis System V.9.3 (SAS Institute, Cary, North Carolina, USA). Means and standard deviations were calculated for all variables using data obtained from each of the three data sets along with data frequencies of tested variables. This method of analysis was initially chosen as it provided an overview of the changes in body mass and activity levels within and between survey years. This was the best way to obtain results as it provided simple mean change information to identify trends and changes within subgroups.

Research by Plotnikoff et al. (2004) states that large population sample studies with subsamples of the population, potentially allows for identification of less physically active groups. Through frequency analysis of change and to overcome overrepresentations of the sample, population subsample analysis was used in relation to body mass values and physical activity, in an attempt to identify the suggested areas of the population that are less active and/ or overweight.

From this, subsequent change analysis was conducted to look at the actual changes in body mass for example, weight, height, waist circumference and BMI from 1997 to 2007 and the change in activity (minutes of brisk walking, moderate-intensity activity, vigorous-intensity activity, moderate and vigorous intensity activity combined and total physical activity made up of brisk walking, moderate-intensity activity and vigorous-intensity activity). Once these values were generated the 95% confidence limit and p value was used to generate an indication of the true significance of the changes over time. To indicate the magnitude and the importance of this change, a magnitude-based inferences model as suggested by Batterham & Hopkins, (2005) was used. With the use of the p value, value of effect statistic, degrees of freedom and the positive and negative threshold values (calculated by multiplying the standard deviation of the baseline or 1997 data (for body mass, height, BMI waist circumference) and 2003 for physical activity by 0.2). The pre-generated equation produced a value for the chances that the true value of the effect statistic was beneficial, harmful or trivial. This analysis allows the change to be considered using probability of substantial changes. This method was chosen as it allows a more clinical approach to estimating worthwhile changes.

Population distribution changes were analysed by comparing each year, within the same gender, the health-related fitness parameters at nine distinct percentile points (1^{st}- 99^{th}) from the 1997 data and the corresponding percentiles from the same gender– age group in the 2007 data. This process was completed for weight, height, waist circumference and BMI. This method was chosen to provide a picture of a trend change along the distribution curve.

Alternatively one of the less used methods of statistical analysis known as matching refers to the selection of unexposed subjects in a cohort study that are identical to the cases in certain characteristics. In a cohort study individual matching involves selecting one or more persons from the unexposed cohort who are identical in one or more characteristics to a person from the exposed cohorts (Garey, 2004). It is stated that matching is done not to increase validity, but rather efficiency of the study (Garey, 2004). Matching analysis is also useful for looking at the effects when controlling for a confounding variable. In this case I am going to determine the effect of changes in physical activity on BMI.

Using a similar procedure to Olds et al. (2007), I wanted to determine to what extent changes in physical activity were associated to changes in fatness (BMI). To do this I matched the participants in the 2003 and 2007 data sets (the physical activity data was not available in the 1997 survey) for gender and age (to within 2 years), and physical activity (minutes of moderate to vigorous intensity weekly physical activity to within 5%). The changes in BMI in the matched data set were then compared to the complete data sets (i.e. all participants in the 2003 and 2007 data sets) to estimate to what degree the change in BMI could be associated to changes in physical activity levels. A type I error of 5% was chosen for declaration of statistical significance; precision of estimates were represented by the 95% confidence limits (CL, the likely range of true value).

Current New Zealand Ministry of Health guidelines for physical activity (30 minutes of physical activity on at least 5 days of the week) were used to calculate the proportion of the survey population meeting the physical activity guidelines. This method was used as it provides the New Zealand baseline for health and has been validated as an appropriate measure of activity.

The physical inactivity analysis consisted of separating the data by year and gender and running an analysis on any participants that indicated that they had completed less than 30 minutes of any physical activity over the seven day recall period. The analysis for the association between BMI and inactivity consisted of selecting all of the participants that were identified as inactive and generating the frequencies of those inactive participants that occur within each of the four BMI categories. This method was chosen as it allows identification of the trends in inactivity by each BMI group over time and for age, gender and ethnicity.

Finally I used linear regression within Microsoft Excel using the forecast formula, from all of the data points from all of the years to predict what the mean BMI of the population may be in 2017, (ten years from the last recorded data within this study).

3.8 Limitations

The main methodological limitation within this study was the lack of a third existing survey dataset that has measured physical activity within the last decade or so for comparison. The most current 2008/2009 National Nutrition Survey does not include any physical activity information so due to time and consent constraints, it was considered of no greater importance. The next New Zealand Health Survey is set to be released around the time of this study being completed.

Another limitation with self-reported physical activity is a tendency to overestimate activity (SPARC, 2004). The interviewer just recorded the physical activity recall answers given by the participant, so inaccuracies may be present in terms of understanding of the questions asked and recall on frequency, intensity and duration.

Additional limitations were the chosen subject ratios, as they were not in line with the New Zealand population with significant over-representation of Maori and females particularly. The ethnic over-representation was a predetermined design prerequisite by the Ministry of Health to gain a greater wealth of knowledge on ethnic minorities. It is unclear whether the gender frequencies were deliberate or just the result of survey sampling. The limitation of oversampling makes generalisations and representativeness of the results difficult.

More limitations will be debated further within the discussion chapter.

Chapter 4

Results

The results chapter reports the findings from the compiled datasets including percentages, means, and magnitude based inferences, as well as results of the matching analysis and distributional percentile changes. Subjects were adults 18 years of age and over and taken from a large sample of the New Zealand population. The total number of participants over the three compiled datasets totalled 28,550 people comprised of 11,558 males (40%) and 16,992 females (60%). The New Zealand population at the time of the last survey was 49% males and 51% females. Ethnicity is also significantly over-represented in terms of Maori participants (28.8%) and under-represented by Europeans (57.6%). The New Zealand population in 2006 was 15% Maori and 77% European. There is a normal distribution across the seven age groups, five deprivation levels and appropriate ratios of urban-to-rural participants (Table 1).

Table 1 Demographic percentages of the participants.

Variables	1997	2003	2007	Total
Gender				
Male	1843 (41%)	4713 (39%)	5002 (42%)	11558 (40%)
Female	2606 (59%)	7464 (61%)	6922 (58%)	16992 (60%)
Age Group				
18-24	413 (9.3%)	1214 (10.0%)	1099 (9.2%)	2726 (9.5%)
25-34	971 (21.8%)	2344 (19.3%)	2080 (17.4%)	5395 (18.9%)
35-44	993 (22.3%)	2695 (22.1%)	2577 (21.6%)	6265 (21.9%)
45-54	673 (15.1%)	2040 (16.8%)	2079 (17.4%)	4792 (16.8%)
55-64	582 (13.1%)	1678 (13.8%)	1729 (14.5%)	3989 (14.0%)
65-74	507 (11.4%)	1236 (10.2%)	1304 (10.9%)	3047 (10.7%)
75+	310 (7.0%)	970 (8.0%)	1056 (8.9%)	2336 (8.2%)
Ethnicity				
Maori	495 (11.1%)	3953 (32.5%)	2926 (24.5%)	7374 (28.8%)
Pacific	256 (5.8%)	875 (7.2%)	836 (7.0%)	1967 (6.9%)
Asian	87 (2.0%)	1131 (9.3%)	1402 (11.8%)	2620 (9.2%)
Other	22 (0.5%)	61 (0.5%)	72 (0.6%)	155 (0.5%)
European	3589 (80.7%)	6157 (50.6%)	6688 (56.1%)	16434(57.6%)
Location				
Urban	3016 (67.8%)	9591 (78.8%)	9268 (77.7%)	21875(76.6%)
Rural	1433 (32.2%)	2586 (21.2%)	2656 (22.3%)	6675 (23.4%)
Deprivation				
1. Least	.	1540 (12.7%)	1926 (16.2%)	3466(14%)
2	.	1813 (14.9%)	2043 (17.1%)	3856(16%)
3	.	2311 (19.0%)	2404 (20.2%)	4715(20%)
4	.	4836 (39.8%)	2610 (21.9%)	7446(31%)
5. Most	.	1648 (13.6%)	2941 (24.7%)	4589(19%)

Data were frequencies and percentages in brackets (Data for the 1997 deprivation was not comparable with 2003 and 2007 and has been omitted).

4.1 Body mass

While there was no substantial change in the height of the participants between 1997 and 2007, body weight increased substantially in both genders over the time period (Table 2). In addition, both males and females showed an increase in waist circumference and BMI over the ten year period.

Table 2 Mean changes in the body composition of the participants from 1997-2007

Variable	1997	2003	2007	1997 - 2007 Change	95% CI	P	Chances that the true difference is substantially positive, trivial or negative	
Weight								
Male	81.9kg	84.8kg	86.7kg	4.8kg	3.9- 5.8	<.0001	91/9/0	Likely positive
Female	70.2kg	72.8kg	73.9kg	3.7kg	2.8- 4.5	<.0001	70/30/0	Possibly positive
Height								
Male	174.5cm	173.9cm	174.5cm	-.03cm	-.41- .36	0.8863	0/100/0	Most likely trivial
Female	161.6cm	161.6cm	161.7cm	.08cm	-.26- .41	0.6530	0/100/0	Most likely trivial
Waist								
Male	94.6cm	97.9cm	97.4cm	2.8cm	2.1- 3.6	<.0001	64/36/0	Possibly positive
Female	83.8cm	88.5cm	87.4cm	3.6cm	3.0- 4.3	<.0001	84/16/0	Likely positive
BMI								
Male	26.9kg/m^2	28.0kg/m^2	28.4kg/m^2	1.6kg/m^2	1.2-1.9	<.0001	94/6/0	Likely positive
Female	26.9kg/m^2	27.9kg/m^2	28.3kg/m^2	1.3kg/m^2	1.0-1.6	<.0001	61/39/0	Possibly positive

Data were means comparing 1997 to 2007 in terms of variables changed, 95% confidence limits, p value and magnitude based inferences from p values.

Table 3 Changes in the distribution of BMI categories from 1997-2007.

BMI Category	1997	2003	2007
Men			
Underweight	3 (0.17%)	32 (0.72%)	27 (0.55%)
Normal weight	660 (37.14%)	1325 (29.86%)	1220 (25.08%)
Overweight	756 (42.54%)	1776 (40.02%)	2069 (42.53%)
Obese	358 (20.15%)	1305 (29.41%)	1549 (31.84%)
Women			
Underweight	37 (1.53%)	131 (2.00%)	49 (0.78%)
Normal weight	1046 (43.17%)	2476 (37.80%)	2280 (36.36%)
Overweight	742 (30.62%)	1870 (28.55%)	1903 (30.35%)
Obese	598 (24.68%)	2073 (31.65%)	2039 (32.51%)

Data are frequencies and percentages in brackets

Substantial increases were found in the incidence of participants classified as obese for both males and females over the ten year period with the proportion of males increasing by approximately 12% and females by approximately 8%. These increases in the frequencies of participants being classified as obese is a result of the normal weight classification decreasing as more people move into the higher weight ranges. The greatest change in frequencies can be seen from the 1997 to the 2002/03 data. Of mention was the decrease in overweight in 2003 for both males and females and the later increase in 2007. Although these results were largely similar for males and females especially in terms of their obesity rates being within 1% of each other the same cannot be said for ethnicity and age. The percentage of individuals overweight or obese was significantly higher in the Maori and Pacific Island groups for both males and females. Asian males had the largest increase in the percentage of individuals overweight and obese from 1997 to 2007, while Pacific Islanders remain the ethnicity with the most individuals overweight and obese across both genders. The incidence of overweightness and obesity tends to increase with age up to the 65-74 age bracket (Table 4). Also refer to Appendix C.

Table 4 Percentage of overweight or obese participants by ethnicity and age

Ethnicity		**1997**	**2007**
Male	Maori	83	84
	Pacific	89	94
	Asian	32	54
	Other	56	54
	European	59	73
Female	Maori	71	75
	Pacific	84	90
	Asian	25	36
	Other	55	53
	European	52	60
Age		**1997**	**2007**
Male	18-24	41	50
	25-34	52	69
	35-44	64	77
	45-54	72	78
	55-64	75	81
	65-74	68	81
	75+	55	73
Female	18-24	39	47
	25-34	48	60
	35-44	53	61
	45-54	63	65
	55-64	65	71
	65-74	65	72
	75+	55	61

Data are percentages

Table 5 BMI levels in the various subgroups for the three surveys between 1997 and 2007

Variable	1997	2003	2007	Change/ cl 1997-2007	p	Chances that the true difference is substantially positive, trivial or negative	
Gender							
Male	26.87 ± 4.75	27.99 ±5.53	28.44 ±5.33	1.6 (1.2-1.9)	<.0001	94.3/5.7/0.0	Likely positive
Female	26.92 ±6.04	27.87 ±6.79	28.25 ± 6.79	1.3 (1.0-1.6)	<.0001	60.8/39.2/0.0	Possibly positive
Age							
18-24	25.31 ±5.37	25.58±6.12	26.30±6.16	1.0 (0.3-1.7)	0.0062	42.0/52.0/0.0	Possibly trivial
25-34	26.23 ±5.52	27.47±6.22	28.09±6.42	1.9 (1.4-2.3)	<.0001	94.8/5.2/0.0	Likely positive
35-44	26.92± 5.48	27.98±6.69	28.49±6.34	1.6 (1.1-2.0)	<.0001	89.0/11.0/0.0	Likely positive
45-54	28.00±5.87	28.88±6.72	28.97±6.54	1.0 (0.4-1.5)	0.0004	26.9/73.1/0.0	Possibly trivial
55-64	28.01±5.19	29.25±6.04	29.25±6.05	1.2 (0.7-1.8)	<.0001	70.7/30.0/0.0	Possibly positive
65-74	27.04±4.75	28.56±5.56	28.88±5.48	1.8 (1.2-2.5)	<.0001	96.7/3.3/0.0	Very likely positive
75+	26.12±6.16	26.50±4.77	26.96±4.85	0.8 (0.0-1.6)	0.0437	13.8/86.2/0.0	Likely trivial
Ethnicity							
Maori	29.57±6.46	30.35±6.91	30.48±6.99	0.9 (0.3-1.5)	0.0019	8.8/91.2/0.0	Likely trivial
Pacific	32.04±6.58	32.47±6.99	33.65±7.39	1.6 (0.8-2.5)	0.0002	74.5/25.5/0.0	Possibly positive
Asian	23.64±3.45	23.27±3.99	24.89±4.22	1.2 (-0.0-2.5)	0.0535	79.4/20.5/0.1	Likely positive
Other	26.21±3.14	26.26±5.41	26.40±5.26	0.2 (-2.6-3.0)	0.8930	38.7/32.4/28.9	Unclear
European	26.29±5.06	26.74±5.17	27.51±5.25	1.2 (1.0-1.5)	<0.0001	72.9/27.1/0.0	Possibly positive
Location							
Urban	26.88v5.59	27.62±6.25	28.23±6.25	1.3 (1.1-1.6)	<.0001	70.7/29.3/0.0	Possibly positive
Rural	26.93±5.42	29.10±6.41	28.68±6.00	1.7 (1.3-2.2)	<.0001	92.1/7.9/0.0	Likely positive
Deprivation							
1.Least	.	26.49±5.17	27.16±5.07	0.7 (0.3-1.1)	0.0015	6.5/93.5/0.0	Likely trivial
2.	.	26.98±5.68	27.27±5.23	0.3 (-0.1-0.7)	0.1365	0.0/100/0.0	Most likely trivial
3.	.	27.70±6.09	27.90±5.99	0.2 (-0.2-0.6)	0.2588	0.0/100/0.0	Most likely trivial
4.	.	29.58±7.05	28.07±5.85	-1.5 (-1.8--1.2)	<.0001	0.0/40.8/59.2	Possibly negative
5.Most	.	26.01±4.78	30.42±7.35	4.4 (4.0-4.8)	<.0001	99.9/0.1/0.0	Most likely positive

Data are means comparing 1997 to 2007, lower and upper limits, p value and 95% confidence limits and magnitude based inferences from p values. (Data for the 1997 deprivation was not comparable with 2003 and 2007).

The same BMI gender effects were seen again in terms of change. Males and females were found to have almost the same BMI value over the years, both moving from approximately 26 kg/m^2 in 1997 to 28 kg/m^2 in 2007. The results over the age groups show that all but the 75+ group had a mean increase of 1 or more kg/m^2 over the ten year period. The greatest change was in the 25-34 year old group with a mean change of 1.9kg/m^2 followed by 1.8 kg/m^2 for the 65-74 year old age group and 1.6 kg/m^2 for the 35-44 year old group. When classified by ethnicity, a mean increase of 1.6 kg/m^2 for Pacific Islanders produced a 'possibly positive' statistic and the 1.2kg/m^2 increase for Asian and European participants is likewise substantial. Participants that lived in rural areas increased their BMI values by 1.7kg/m^2 and urban participants by 1.3kg/m^2 over the 10 year study period. Finally, in terms of deprivation the 4.4kg/m^2 increase within the most deprived category is the greatest increase. The category second most deprived however had a -1.5kg/m^2 change. The other levels from 1 to 3 in terms of deprivation had little change.

Another way to analyse change over time is to look at the data as a distribution. In Figure 1 the distributions for BMI, waist circumference and weight for the 1997 and 2007 data sets are presented. The intercepting lines within each graph show the recommended cut-off points for health. BMI, waist circumference and weight start to become higher in the 2007 data (compared to the 1997) from approximately the 10th percentile onwards. The greatest change was found at the 99th percentile, (particularly for females), indicating increased central adiposity, and overall weight increases were highest in the biggest people. The majority of the values were well above the recommended cut-off points for health.

4.2 Physical activity

The following results (Table 6) show the mean changes in physical activity from 2002/03 to 2006/07, accompanied with subsequent tables (Tables 7-11) to show changes in the various physical activity levels in the specified population groups. Also refer to Appendix D.

Compared to females, males completed 81 minutes more of brisk walking, 189 minutes more of moderate intensity physical activity, and 116 minutes more of vigorous intensity physical activity in 2007. Participants aged 75+ were the least active over all intensities. Maori participants had the highest levels over all intensities of activity, while Asian participants were the lowest. Rural participants completed 383 minutes more of total activity in 2007 over the recorded week than urban participants. Finally, deprivation had little effect on physical activity levels. Also refer to Appendix D.

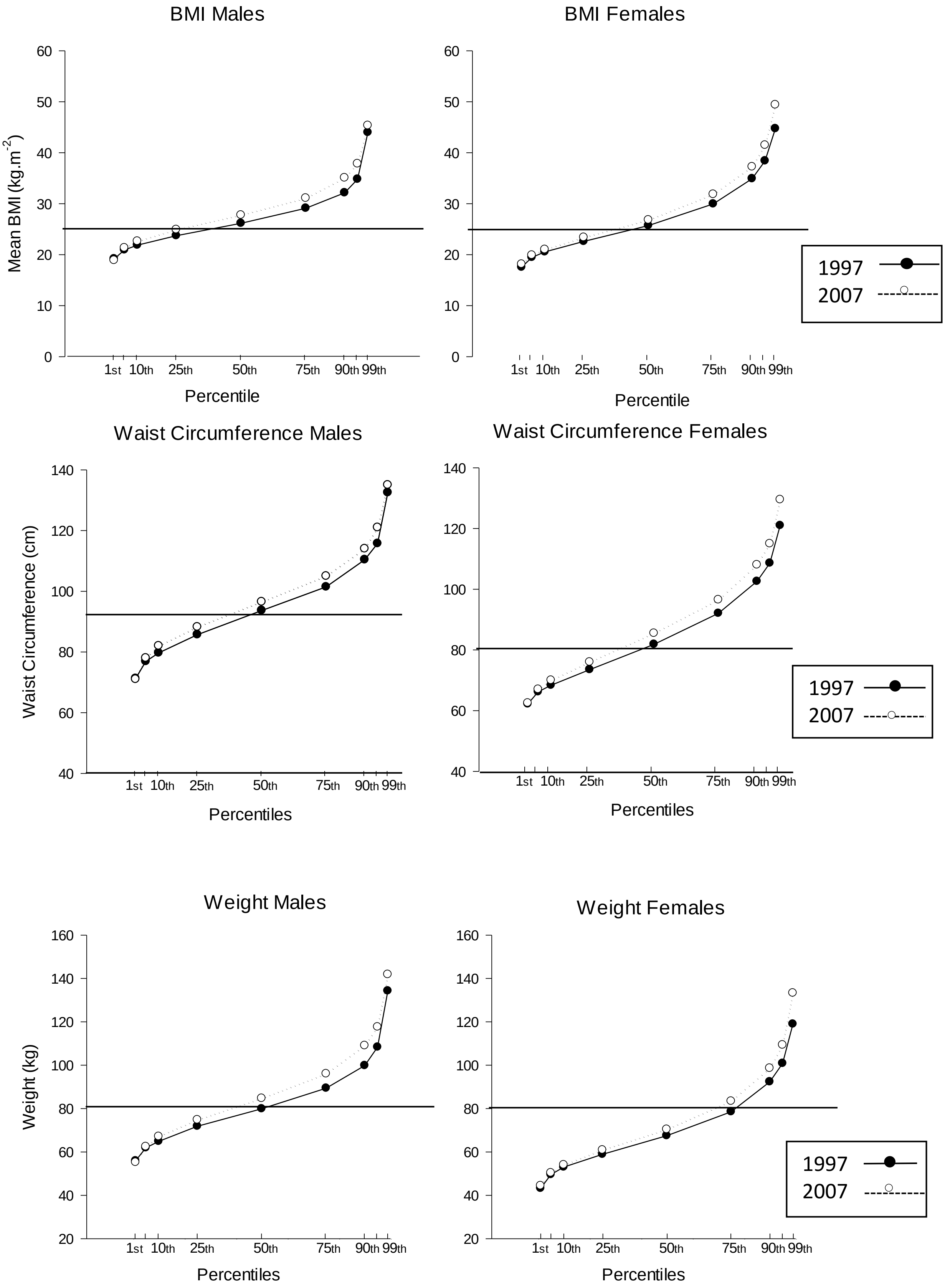

Figure 1 Distributional percentiles for BMI, waist circumference and weight

Table 6 Mean physical activity total minutes over seven days

	Walking		Moderate Activity		Vigorous Activity		Mod & Vig Activity		Total Activity	
Variables	**2003**	**2007**	**2003**	**2007**	**2003**	**2007**	**2003**	**2007**	**2003**	**2007**
Gender										
Male	196 ± 454	260 ± 513	595 ± 909	584 ± 822	228 ± 530	200± 431	823 ± 1109	784± 1020	1019 ± 1270	1043 ± 1246
Female	142 ± 347	179 ± 367	418 ± 685	395 ± 631	85± 285	84± 239	504 ± 779	479 ± 730	645 ± 905	657 ± 884
Age										
18-24	167 ± 397	234 ± 451	391 ± 720	445 ± 713	217± 511	182 ± 411	608 ± 932	627 ± 890	775± 1067	861 ± 1078
25-34	170 ± 431	227 ± 462	474 ± 798	476 ± 744	163 ± 422	158 ± 360	637 ± 957	634 ± 915	807 ± 1116	861 ± 1130
35-44	181 ± 419	241 ± 495	511 ± 832	510 ± 784	171 ± 454	157 ± 361	682 ± 999	667 ± 941	863 ± 1163	907 ± 1171
45-54	187 ± 418	236 ± 454	562 ± 840	529 ± 746	148 ± 410	157 ± 375	710 ± 993	685 ± 935	897 ± 1141	921 ± 1137
55-64	169 ± 390	212 ± 432	551 ± 801	526 ± 750	117± 376	108 ± 298	668 ± 941	633 ± 869	837 ± 1069	845 ± 1019
65-74	123 ± 277	173 ± 343	489 ± 731	446 ± 629	63 ± 232	80 ± 243	551 ± 806	526 ± 729	674 ± 884	699 ± 876
75+	78 ± 253	97 ± 203	299 ± 514	258 ± 477	30 ± 155	29 ± 159	329 ± 564	287 ± 548	407 ± 668	383 ± 609
Ethnicity										
Maori	197 ± 465	259 ± 493	585 ± 842	564± 795	193 ± 506	191 ± 425	777 ± 1025	755 ± 994	974 ± 1194	1013 ± 1221
Pacific	205 ± 458	222 ± 487	303 ± 581	406 ± 717	154 ± 433	155 ± 409	457 ± 749	561 ± 890	662 ± 947	783 ± 1116
Asian	111 ± 276	191 ± 420	164 ± 411	304 ± 577	58 ± 206	74 ± 270	222 ± 487	378 ± 693	333 ± 598	569 ± 890
Other	108 ± 152	182 ± 295	330 ± 654	330 ± 651	68 ± 312	105 ± 257	398 ± 707	435 ± 784	506 ± 727	618 ± 896
European	145 ± 347	196 ± 405	511 ± 804	481 ± 713	121 ± 346	117 ± 292	631 ± 934	597 ± 843	777 ± 1057	794 ± 1011
Location										
Urban	149 ± 365	197 ± 416	413 ± 707	414 ± 672	122 ± 370	122 ± 320	534 ± 843	537 ± 815	683 ± 965	734 ± 992
Rural	215 ± 479	266 ± 497	761 ± 971	684 ± 848	210 ± 505	168 ± 393	971 ± 1149	851 ± 1027	1186 ± 1343	1117 ± 1254
Deprivation										
1.Least	160± 378	184 ± 362	515 ± 816	428 ± 645	116 ± 313	117 ± 265	632 ± 934	544 ± 757	791± 1061	729 ± 902
2.	133 ± 334	217 ± 433	459 ± 761	487 ± 745	116 ± 353	135 ± 315	575 ± 893	621 ± 906	708 ± 1010	838 ± 1096
3.	150 ± 377	210 ± 426	438 ± 753	492 ± 735	138 ± 418	124 ± 321	577 ± 893	616 ± 879	727 ± 1025	826 ± 1051
4.	187 ± 445	215 ± 443	515 ± 804	462 ± 714	167 ± 471	125 ± 329	682 ± 986	587 ± 859	869 ± 1157	803 ± 1054
5.Most	145 ± 319	228 ± 481	485 ± 760	492 ± 754	115 ± 279	155 ± 410	600 ± 868	647 ± 938	745 ± 976	875 ± 1167

Data are means ± SD. Walking; the total minutes spent brisk walking per week. Moderate; the total minutes spent in moderate physical activity per week. Vigorous; the total minutes spent in vigorous physical activity per week. Mod & Vig Activity; the total minutes spent in moderate and vigorous physical activity per week. Total activity; the total minutes spent brisk walking, moderate and vigorous physical activity combined.

Table 7 Mean changes in brisk walking between 2003 and 2007.

Variable	Change (2007-2003)	95% CI	P	Chances that the true difference is substantially positive, trivial or negative	
Gender					
Male	63	47-80	<0.0001	4.3/95.7/0.0	Very Likely trivial
Female	37	23-50	<0.0001	0.0/100/0.0	Very Likely trivial
Age Group					
18-24	67	33-101	<0.0001	23.6/76.4/0.0	Likely trivial
25-34	57	32-81	<0.0001	2.3/97.7/0.0	Very likely trivial
35-44	59	37- 82	<0.0001	5.1/94.9/0.0	Likely trivial
45-54	49	24- 74	0.0001	0.3/99.7/0.0	Most likely trivial
55-64	44	16- 71	0.0021	0.9/99.1/0.0	Very likely trivial
65-74	50	18-82	0.0023	37.1/62.9/0.0	Possibly trivial
75+	18	-18- 54	0.3176	3.5/96.5/0.0	Very likely trivial
Ethnicity					
Maori	62	42-82	<0.0001	2.6/97.4/0.0	Very likely trivial
Pacific	17	-23-56	0.4044	0.0/100/0.0	Most likely trivial
Asian	81	48-114	<0.0001	89.2/10.8/0.0	**Likely positive**
Other	74	-67- 215	0.3021	72.8/19.9/7.3	Unclear
European	51	37- 65	<0.0001	8.0/92.0/0.0	Likely trivial
Location					
Urban	49	37-61	<0.0001	2.8/97.2/0.0	Very likely trivial
Rural	51	28-73	<0.0001	0.0/100/0.0	Most likely trivial
Deprivation					
1. Least	25	-3.0- 53	0.0806	0.0/100/0.0	Most likely trivial
2	84	58- 110	<0.0001	78.7/21.3/0.0	**Likely positive**
3	59	36-83	<0.0001	14.0/86.9/0.0	Likely trivial
4	28	8.6- 48	0.0050	0.0/100/0.0	Most likely trivial
5. Most	84	59- 109	<0.0001	82.5/17.5/0.0	**Likely positive**

Data were mean minutes of activity per week, 95 % confidence limits, p value and magnitude based inferences from p values.

There was little difference in the amounts of brisk walking reported between 2003 and 2007, except for a likely increase in Asian individuals and those at either end of the deprivation scale.

Table 8 Mean changes in moderate intensity activity between 2003 and 2007.

Variable	Change (2007-2003)	95% Cl	P	Chances that the true difference is substantially positive, trivial or negative	
Gender					
Male	-12	-41- 18	0.4482	0.0/100/0.0	Most likely trivial
Female	-23	-48- 1.2	0.0619	0.0/100/0.0	Most likely trivial
Age Group					
18-24	54	-7.2- 115	0.0837	0.2/99.8/0.0	Most likely trivial
25-34	2.0	-42- 46	0.9290	0.0/100/0.0	Most likely trivial
35-44	-0.95	-42- 40	0.9633	0.0/100/0.0	Most likely trivial
45-54	-33	-79- 13	0.1550	0.0/100/0.0	Most likely trivial
55-64	-25	-76- 25	0.3223	0.0/100/0.0	Most likely trivial
65-74	-43	-101- 15	0.1495	0.0/100/0.0	Most likely trivial
75+	-41	-107- 24	0.2156	0.0/96.9/3.1	Very likely trivial
Ethnicity					
Maori	-20	-56- 15	0.2649	0.0/100/0.0	Most likely trivial
Pacific	103	32- 174	0.0043	35.7/64.3/0.0	Possibly trivial
Asian	140	82- 199	<.0001	94.6/5.4/0.0	**Likely positive**
Other	-0.3	-255- 255	0.9979	12.5/74.9/12.6	Unclear
European	-31	-56- -4.6	0.0208	0.0/100/0.0	Most likely trivial
Location					
Urban	1.4	-20- 23	0.8957	0.0/100/0.0	Most likely trivial
Rural	-77	-118- -37	0.0002	0.0/100/0.0	Most likely trivial
Deprivation					
1. Least	-88	-138- -37	0.0007	0.0/99.8/0.2	Most likely trivial
2	28	-20- 75	0.2556	0.0/100/0.0	Most likely trivial
3	54	11- 97	0.0140	0.0/100/0.0	Most likely trivial
4	-52	-88- -17	0.0042	0.0/100/0.0	Most likely trivial
5. Most	6.8	-39- 52	0.7688	0.0/100/0.0	Most likely trivial

Data were mean minutes of activity per week, 95 % confidence limits, p value and magnitude based inferences from p values.

The amount of time spent in moderate intensity physical activity in most cases changed little between 2003 and 2007, apart from a substantial increase by Asian participants (140 min/week, 95% CI 82-199).

Table 9 Mean changes in vigorous intensity activity between 2003 and 2007.

Variable	Change (2007-2003)	95% CI	P	Chances that the true difference is substantially positive, trivial or negative	
Gender					
Male	-28	-43- -13	0.0002	0.0/100/0.0	Most likely trivial
Female	-1.4	-13- 11	0.8208	0.0/100/0.0	Most likely trivial
Age Group					
18-24	-35	-66- -5.2	0.0217	0.0/100/0.0	Most likely trivial
25-34	-4.6	-26- 17	0.6803	0.0/100/0.0	Most likely trivial
35-44	-14	-34- 6.4	0.1826	0.0/100/0.0	Most likely trivial
45-54	8.9	-14- 32	0.4385	0.0/100/0.0	Most likely trivial
55-64	-9.6	-34- 15	0.4508	0.0/100/0.0	Most likely trivial
65-74	17	-11- 46	0.2342	2.0/98.0/0.0	Very likely trivial
75+	-1.1	-33- 31	0.9462	2.2/94.8/3.0	Likely trivial
Ethnicity					
Maori	-1.9	-20- 16	0.8333	0.0/100/0.0	Most likely trivial
Pacific	1.2	-34- 36	0.9468	0.0/100/0.0	Most likely trivial
Asian	15	-14- 44	0.3014	3.6/96.4/0.0	Very likely trivial
Other	38	-89- 164	0.5599	35.4/58.4/6.2	Unclear
European	-3.8	-17- 9.0	0.5609	0.0/100/0.0	Most likely trivial
Location					
Urban	0.7	-9.9- 11	0.8905	0.0/100/0.0	Most likely trivial
Rural	-42	-62- 22	<.0001	0.0/100/0.0	Most likely trivial
Deprivation					
1. Least	0.48	-24- 25	0.9697	0.0/100/0.0	Most likely trivial
2	19	-4.6- 43	0.1145	0.0/100/0.0	Most likely trivial
3	-14	-35- 7.1	0.1910	0.0/100/0.0	Most likely trivial
4	-43	-60- -25	<.0001	0.0/100/0.0	Most likely trivial
5. Most	40	17- 62	0.0005	8.5/91.5/0.0	Likely trivial

Data were mean minutes of activity per week, 95 % confidence limits, p value and magnitude based inferences from p values.

Similar to moderate intensity physical activity the number of minutes spent in vigorous intensity physical activity changed little over the four years with all changes being trivial or unclear.

Table 10 Mean changes in moderate and vigorous intensity activity between 2003 and 2007.

Variable	Change (2007-2003)	95% CI	P	Chances that the true difference is substantially positive, trivial or negative	
Gender					
Male	-39	-74- -3.2	0.0328	0.0/100/0.0	Most likely trivial
Female	-25	-54- 4.3	0.0949	0.0/100/0.0	Most likely trivial
Age Group					
18-24	19	-55- 92	0.6173	0.0/100/0.0	Most likely trivial
25-34	-2.0	-55- 51	0.9402	0.0/100/0.0	Most likely trivial
35-44	-14	-63- 34	0.5603	0.0/100/0.0	Most likely trivial
45-54	-24	-79- 31	0.3840	0.0/100/0.0	Most likely trivial
55-64	-35	-95- 25	0.2565	0.0/100/0.0	Most likely trivial
65-74	-26	-96- 45	0.4753	0.0/100/0.0	Most likely trivial
75+	-42	-121- 36	0.2885	0.0/96.3/3.7	Very likely trivial
Ethnicity					
Maori	-23	-65- 20	0.3005	0.0/100/0.0	Most likely trivial
Pacific	104	19- 189	0.0163	14.5/85.5/0.0	Likely trivial
Asian	156	85- 226	<.0001	92.8/7.2/0.0	**Likely positive**
Other	37	-268- 343	0.8109	25.0/62.6/12.4	Unclear
European	-34	-65- -2.9	0.0320	0.0/100/0.0	Most likely trivial
Location					
Urban	2.4	-23- 28	0.8538	0.0/100/0.0	Most likely trivial
Rural	-120	-168- -72	<.0001	0.0/100/0.0	Most likely trivial
Deprivation					
1	-87	-147- -26	0.0051	0.0/99.9/0.1	Most likely trivial
2	46	-11- 104	0.1125	0.0/100/0.0	Most likely trivial
3	39	-12- 91	0.1355	0.0/100/0.0	Most likely trivial
4	-94	-137- -51	<.0001	0.0/100/0.0	Most likely trivial
5	46	-8.2- 101	0.0959	0.0/100/0.0	Most likely trivial

Data were mean minutes of activity per week, 95 % confidence limits, p value and magnitude based inferences from p values.

Similar to moderate or vigorous the moderate and vigorous physical activity levels changed little over the 4 years of the study. Asian participants were the only participants to have a significant increase of 156 minutes.

Table 11 Mean changes in total physical activity between 2003 and 2007.

Variable	Change (2007-2003)	95% Cl	P	Chances that the true difference is substantially positive, trivial or negative	
Gender					
Male	24	-18- 66	0.2685	0.0/100/0.0	Most likely trivial
Female	12	-22- 47	0.4926	0.0/100/0.0	Most likely trivial
Age Group					
18-24	86	-1.0- 173	0.0528	0.2/99.8/0.0	Most likely trivial
25-34	54	-8.5- 117	0.0902	0.0/100/0.0	Most likely trivial
35-44	44	-13- 102	0.1296	0.0/100/0.0	Most likely trivial
45-54	25	-40- 90	0.4570	0.0/100/0.0	Most likely trivial
55-64	8.5	-63- 80	0.8165	0.0/100/0.0	Most likely trivial
65-74	24	-58- 107	0.5634	0.0/100/0.0	Most likely trivial
75+	-24	-117- 69	0.6102	0.0/99.0/1.0	Very likely trivial
Ethnicity					
Maori	40	-11- 90	0.1264	0.0/100/0.0	Most likely trivial
Pacific	121	20- 221	0.0186	9.2/90.8/0.0	Likely trivial
Asian	236	153- 319	<.0001	97.3/2.7/0.0	**Very likely positive**
Other	112	-250- 473	0.5455	42.8/48.9/8.2	Unclear
European	16	-20- 53	0.3801	0.0/100/0.0	Most likely trivial
Location					
Urban	51	21- 81	0.0010	0.0/100/0.0	Most likely trivial
Rural	-69	-127- -12	0.0175	0.0/100/0.0	Most likely trivial
Deprivation					
1. Least	-62	-134- 9.3	0.0880	0.0/100/0.0	Most likely trivial
2	130	63- 198	0.0002	2.0/98.0/0.0	Very likely trivial
3	99	38- 160	0.0015	0.0/100/0.0	Most likely trivial
4	-67	-118- -16	0.0106	0.0/100/0.0	Most likely trivial
5. Most	130	65- 195	<.0001	2.5/97.5/0.0	Very likely trivial

Data were mean minutes of activity per week, 95 % confidence limits, p value and magnitude based inferences from p values.

Overall there was little change in the total physical activity minutes of the participants. Asian participants were the only group to show a substantial increase.

Table 12 shows the results of matching analysis on the datasets. After matching for age, gender and physical activity males in the complete data set increased their BMI from 28.0 in 2003 to 28.4 in 2007 an increase of 1.4%. Females BMI also increased from 27.9 in 2003 to 28.3 in 2007, an increase of 1.4%. The increase in BMI for the matched sample was 1.3% and 1.4% for males and females respectively.

Table 12 Mean age, weekly moderate to vigorous intensity physical activity and BMI for male and female adults in the matched and complete 2003 and 2007 data sets.

	Matched Data Set				Complete Data Set			
	male		female		male		female	
	2003	2007	2003	2007	2003	2007	2003	2007
n	87465	87465	266978	266978	4438	4865	6550	6271
Age (y)	48.9	48.9	44.8	44.8	47.3	17.9	45.9	47.3
Physical activity (min.week^{-1})	358.6	371.1	137.7	139.6	822.2	783.6	503.4	478.5
BMI	28.5	28.8	28.0	28.4	28.0	28.4	27.9	28.3

The below tables and figures show the number of individuals and percentages of the survey sample that were active for 30 minutes or more, over how many days of the self-reported survey week. The physical activity guidelines within New Zealand state that being active for at least 30 minutes on five or more days of the week is advisable (Table 13). Figure 2 shows the percentage of participants active over 5, 6 or 7 days of the week and the totals that meet the guidelines over the two physical activity survey years. The greatest percentage is activity over 7 days of the week followed by 0 days for both years.

Table 13 How many days out of seven were the participants active

	2003			2007	
Day active	**Frequency**	**Per cent**	**Day active**	**Frequency**	**Per cent**
0	2280	18.74	**0**	1776	14.90
1	598	4.91	**1**	773	6.48
2	888	7.30	**2**	1027	8.62
3	1049	8.62	**3**	1136	9.53
4	911	7.49	**4**	1064	8.93
5	1465	12.04	**5**	1566	13.14
6	822	6.75	**6**	817	6.85
7	4156	34.15	**7**	3761	31.55

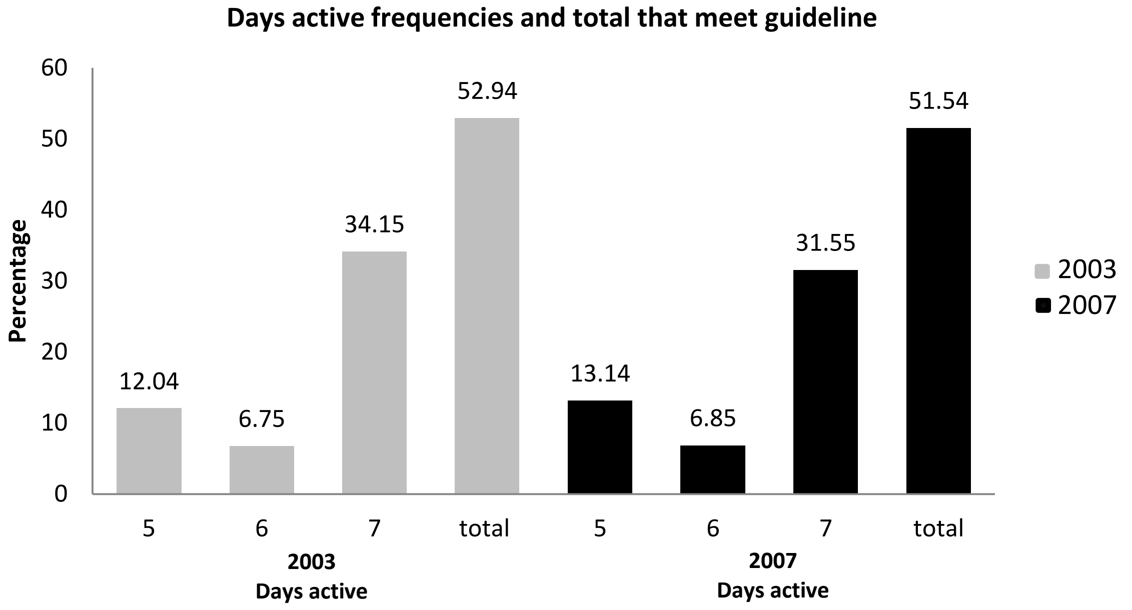

Figure 2 Physical activity guideline percentages of 5 or more days active and totals per year.

Approximately 53% of the study participants in 2003 met the physical activity guidelines (of 30 minutes of physical activity over at least five days of the week) while in 2007 this dropped slightly to 51.5% (Figure 2).

4.3 Physical inactivity

The below figure shows there has been a slight (however non-significant) decrease in the number of participants classified as inactive (completing less than 30 minutes of physical activity over the recorded seven day period) over the two survey data sets for both males and females.

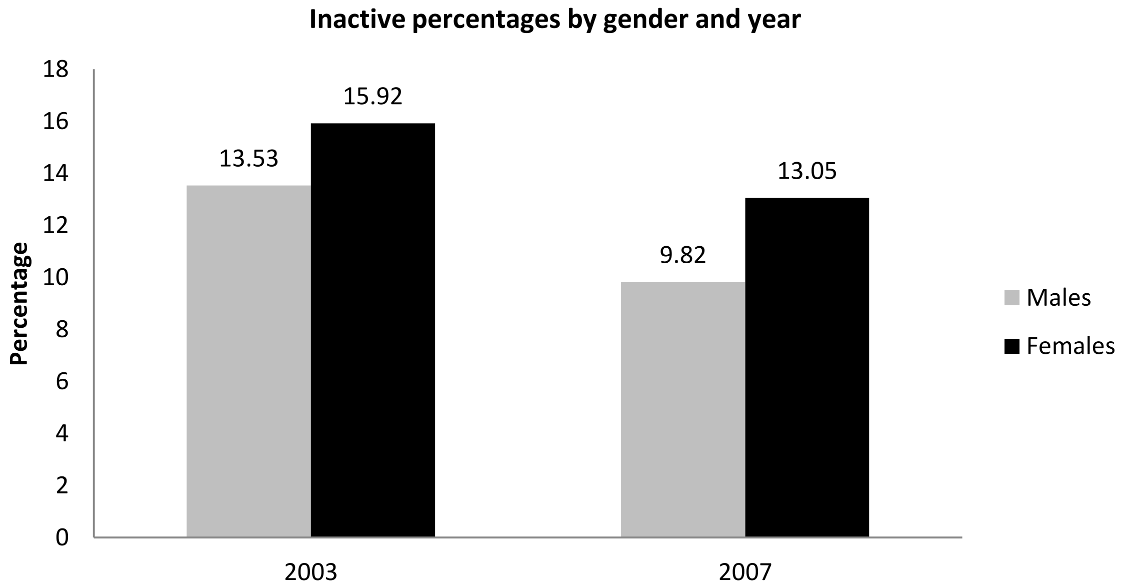

Figure 3 Percentages of participants classified as inactive by gender and year.

4.4 Association between BMI and inactive behaviour

Figure 4 shows all participants that were classified as inactive and the percentage of individuals within each BMI category. The results indicate that the incidence of overweight and obesity increase with inactivity (for example in 2007 in males approximately 80% of those overweight or obese were inactive, i.e. 41% overweight and 38% obese = 79%). In addition, the proportion of those inactive and overweight or obese is increasing overtime (for example in 2007 the percentage overweight or obese and inactive increased by 9% for males and 6% for females from the 2003 data).

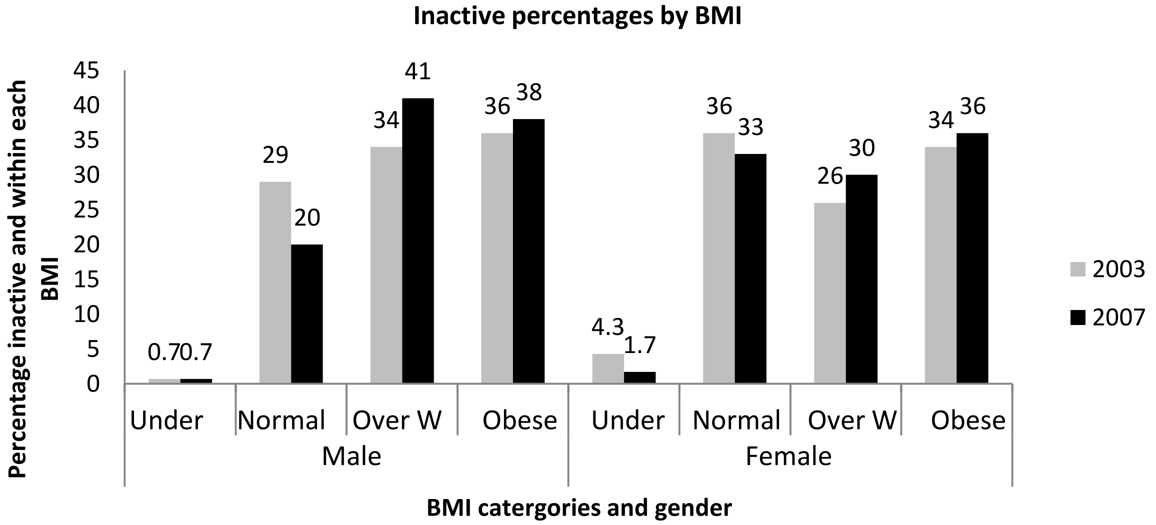

Figure 4 Inactive percentages by BMI for gender and year.

When I analysed the association between ethnicity, BMI, and inactivity, I found that Pacific Islanders were more likely to be inactive and overweight or obese, with a 94% incidence of Pacific Island people being inactive and overweight or obese in 2007. Similarly 84% of Maori who were inactive were also overweight or obese.

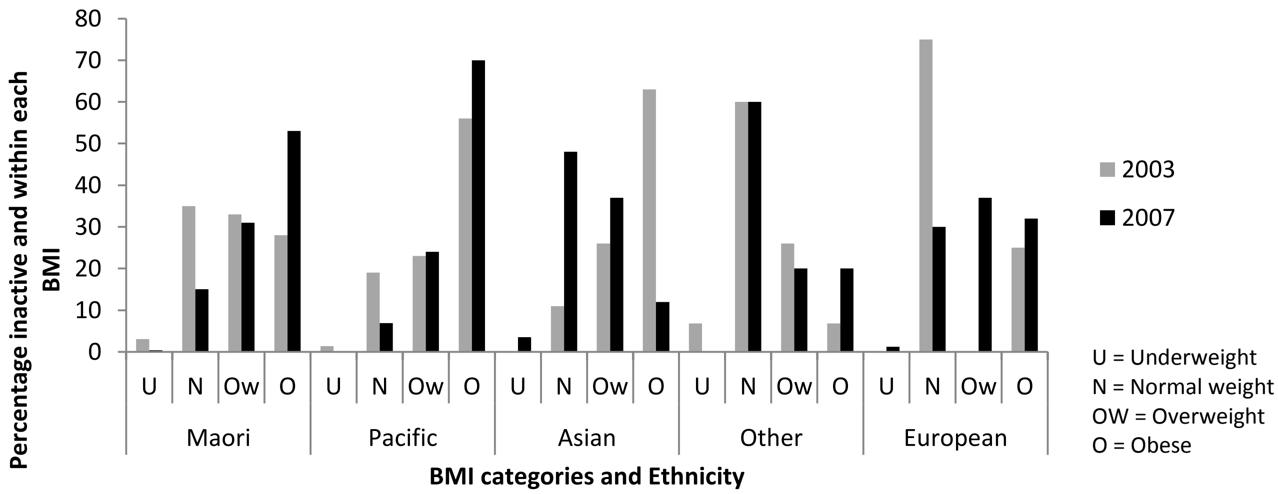

Figure 5 Inactive percentages by BMI for ethnicity and year.

When analysed by age group, I found that the incidence of overweight or obese inactive participants is greatest over middle to older age. The greater incidence begins around 45 and peaks at 65-74 years of age with an 85.9% occurrence. The 18-24 year olds were lowest on 49.7% overweight or obese.

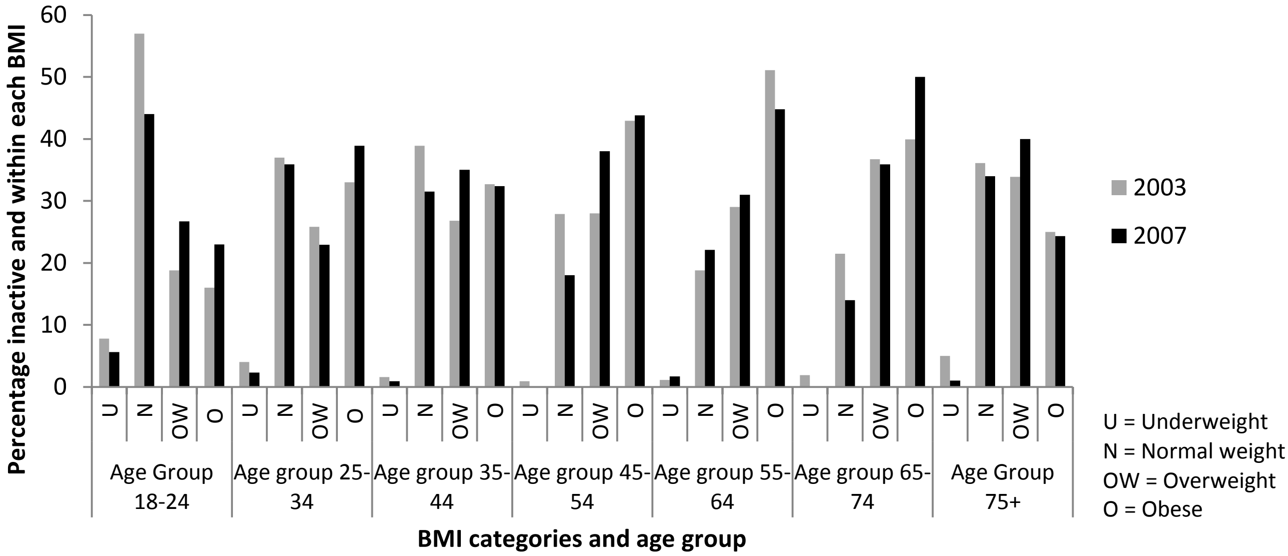

Figure 6 Inactive percentages by BMI for age group and year.

I also used a single linear regression to analyse the BMI trends in males and females over the years. I predict that over the next ten years from 2007 to 2017 males will increase their mean BMI to 30 kg/m^2 and females to 29.5 kg/m^2. The implications of these figures will be discussed below.

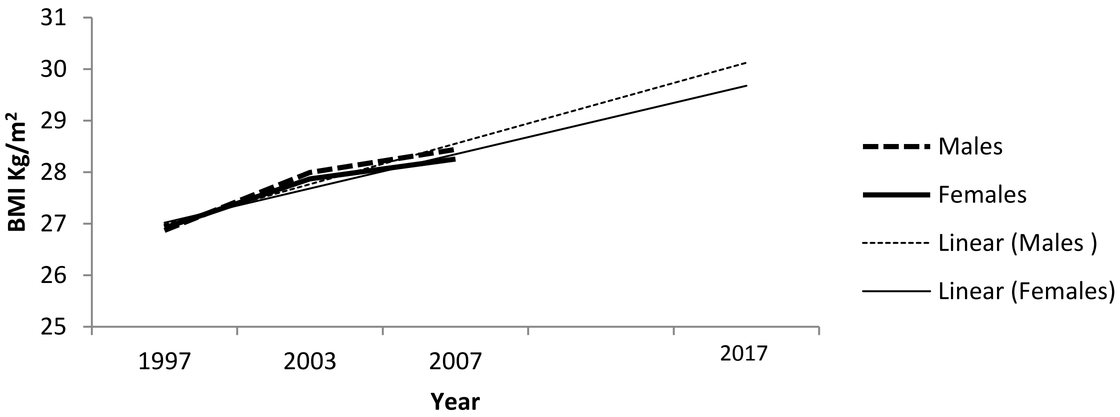

Figure 7 Trend line for BMI by gender and year

The following section is the discussion chapter of the thesis. Within this, the results will be discussed in greater detail, accompanied by the relevant literature associated with the results that were found.

Chapter 5

Discussion

The motivation for this research came out of the need for greater longitudinal and distributional information into the body mass values and physical activity patterns of New Zealand adults. Additional questioning as to whether a relationship exists between an individual's lack of activity and their body mass was also desired. The data analysed was from three health surveys representing the most recent data available. Although several years old, future predictions can be made and ultimately compared to new datasets, as they become available.

5.1 Main findings

5.1.1 Overweightness and obesity continue to rise

There are a number of hypotheses that try to explain the phenomenon of increased body weight. The most plausible explanation for the increases seen in body weight, waist circumference and BMI, suggest obesity is caused by a lack of physical activity and chronic consumption of excess calories (Corsica & Perri, 2003; Skidmore & Yarnell, 2004; Mhurchu et al., 2004; Saris et al., 2010; MOHa, 2012). The outcomes of this study clearly showed not only a mean increase in body weight, but increases in waist circumference and BMI across almost all subgroups over the 10 year period. The findings within this study confirm findings found elsewhere, that the secular trend in body weight has continued, reflecting the growing epidemic of obesity (Cole, 2003 cited in Danubio & Sanna 2008). A mean increase in body weight of 4.8 kilograms for males and 3.7 kilograms for females was found over the 10 year research period. The proportion of people classified as obese for males increased by 11.7%, while females increased by 7.8%. Male BMI values increased by 1.6kg/m^2 while females increased by 1.3kg/m^2. The average BMI is now at a level that exceeds the cut-off points for health, as advised by the World Health Organisation. Any increase above these recommended cut-offs substantially increases the risk of type 2 diabetes, cardiovascular disease, some cancers, musculoskeletal disorders, osteoarthritis (WHOc, 2012), sleep apnoea, reproductive abnormalities (MOHa, 2012; Corsica & Perri, 2003) and gallstones (Corsica & Perri, 2003).

Studies by Elobeid et al. (2007, cited in Walls et al. 2011) and Walls et al. (2007, cited in Walls et al. 2011) suggest that the nature of excess body weight may be changing over time to one of greater central adiposity. Central adiposity is the result of an excess of fat deposition around the abdominal area. An increase in waist circumference is indicative of an increase in central adiposity. Increased central adiposity is a known risk factor in many diseases. There is a growing body of literature suggesting that abdominal adiposity is a more important risk factor for cardiovascular and metabolic disease than is general adiposity (Janssen, Katzmarzyk & Ross, 2004; Taylor et al., 2010). With a 2.8cm mean increase in waist circumference in males and 3.6cm mean increase in females, these statistically significant changes will also increase the health risk of diseases for many New Zealand adults.

While statistics of this nature are useful for showing change, caution should be taken, as they are representing mean values. A problem with using only the mean is that big changes in small proportions of the population could skew these mean values.

5.1.2 **Not everyone is gaining weight**

The results of this study produce conclusive findings that in fact not everyone is gaining weight. Through the use of distributional percentiles, deviations in the distribution give the greatest picture of changes. The data shows that participants within the 1st to approximately the 10th percentile had little change in body weight, waist circumference or BMI (Figure 1). This suggests that during the ten year period not everybody gained body weight, waist circumference and subsequent BMI. These participants within the lowest percentiles managed to maintain a normal weight and did not gain any body mass within the sample. This is similar to the research findings by Turnbull, Barry, Wickens & Crane, (2004) and Albon, Hamlin and Ross, (2010). The same, however, cannot be said for the rest of the distribution as substantial deviations are evident from the 1997 trend line to that of the 2007 trend line (figure 1).

The Ministry of Heath note that although some people are said to be more genetically susceptible to weight gain than others, the rapid increase in the prevalence of obesity in recent years has occurred too quickly to be explained by genetic factors alone. Most experts believe this is due to living in an increasingly ‘obesogenic’ environment (MOHa, 2012). There is however a segment of society maintaining their weight and further research into how they are achieving this within the described ‘obesogenic’ environment may be crucial to better understanding determinants of why some people put on weight while others do not. In particular, are these people more physically active?

5.1.3 **Physical activity**

Fewer than 40% of adults in the western world currently participate in regular physical activity (Seefeldt, Malina & Clark, 2002 cited in Plotnikoff et al., 2004) and 25% of adults are sedentary (Katzmarzy, Gladhill & Shepard, 2000; National centre for health statistics, 1992; 1999; Stephens &

Craig, 1989 cited in Seefeldt, Malina & Clark, 2002). The findings of this study conflict with international trends as 51.5% of New Zealanders were found to be physically active, while only 10% of males and 13% of females were found to be inactive. The trends for physical activity within New Zealand are clearly substantially higher than the participation rates found globally. This may be a result of large physical activity campaigns and proactive local government to encourage physical activity. The availability of green space in New Zealand and our cultural influences to be active in the outdoors may be reasons behind our higher activity rates.

Over the four year study period the reporting of physical inactivity decreased by close to 4% for males and 3% for females. If physical inactivity is decreasing, physical activity must be increasing in some form. This study found that brisk walking increased over the recording period. However, while brisk walking increased, total physical activity did not change suggesting a drop in activity in other areas (e.g. the moderate and vigorous combined physical activity levels dropped in males and female).

Many academics suggest that the current guidelines of 30 minutes per day of moderate to vigorous intensity physical activity over five days per week is too low to prevent weight gain and the growing obesity epidemic. However, since half of the New Zealand population currently do not meet even these less stringent guidelines, there is little hope in trying to get individuals to do even more exercise. But recent research has found that completing less exercise at a higher intensity (less overall time) can produce similar or better health changes than longer (but less intense) exercise (Gibala et al. 2006; Draper et al. 2012; Draper et al. 2012 pp500).

While not a focus of this research many of the suggested reasons for these changes in reduced moderate and vigorous physical activity pursuits include; increases in sedentary work, less active transport, more time spent in front of the television and computer monitors, and the amount of time spent walking and cycling has decreased (Grantmakers of Health, 2001 cited in Skidmore & Yarnell, 2004). The energy cost of housework is said to be reduced and television viewing and related pursuits now monopolize much of the available leisure time of the substantial proportion of the population (Livingstone et al., 2003). Saris et al. (2003) suggest urbanization and the modernization of work and home by technology are significant determinants to physically active lives.

5.1.4 Body weight and physical activity

Overweightness and obesity are the result of a positive energy balance, described as, a long term excess of energy intake (food and beverage consumption) over energy expenditure (basal metabolic rate and physical activity) (MOHa, 2012; Mhurchu et al., 2004). The logical explanation for large body mass increases can best be described through an increase in caloric intake, far exceeding levels of physical activity energy expenditure. But is this in fact the case? This study attempted to investigate to what proportion the increase in fatness (BMI) of our subjects was due to physical activity changes or to other factors which would include calorie intake. This was done by matching for age, gender and physical activity and changes in the BMI of the matched sample almost mirrored those in the complete dataset. When analysing the data through matching analysis almost all (80-90%) of the changes in BMI were attributable to changes in physical activity. Only a small proportion of the variance (less than 20%) could be attributed to factors other than the change in physical activity. Given that the increase in BMI is almost entirely due to the decrease in physical activity (and not other factors like increased caloric consumption), greater education and awareness of this relationship is pivotal.

This is a significant result for this research, along with the results generated for the associations between inactivity and BMI. The results indicate that the number of people that are inactive within the overweight and obese categories is increasing. By contrast, the number of inactive people that were normal and underweight is decreasing, strongly linking weight to inactivity. These findings are consistent with research that suggests overweight subjects tend to be physically inactive in leisure time (Burke, Savage & Manolio, 1992; Gutierrez-Fisac, Regidorm & Rodriguea, 1996; Martinez-Gonzalez et al., 1999 cited in Lahti-Koski et al., 2002), and that the proportion of physically inactive persons increases with increasing BMI (Lindstrom, Isacsson & Merlo, 2003). As high baseline levels of BMI are suggested to predict future low levels of physical activity (Petersen et al., 2004 cited in Wareham, van Sluijs & Ekelund, 2005). It has been found that lower body weights and lower BMI's are associated with higher levels of self-reported physical activity (Corsica & Perri, 2003). Weight increases are attributed to a decline in daily physical activity levels and a clear major factor contributing to the current obesity epidemic affecting both developed and developing countries in the world (Saris et al., 2010).

While physical activity may affect body weight, it is also likely that body weight impacts on physical activity via increased discomfort associated with higher body weight, including higher levels of breathlessness and sweating, and general difficulty in negotiating body movement (Corsica & Perri, 2003). In order for weight loss to occur and be successful in the long term, you must increase caloric debt (by increasing exercise or reducing food intake, or both). It is also important to prevent weight regain once body fat has been lost. Saris et al. (2003) suggest that if we want to prevent weight gain or regain, current activity guidelines are likely to be insufficient for many individuals. Compelling evidence indicates that prevention of weight regain in formerly obese individuals requires 60-90 minutes of moderate intensity physical activity, or smaller amounts of vigorous intensity physical activity together with moderate intensity activity of approximately 45 to 60 minutes per day, seven days per week (Saris et al., 2003). Such information is important as a high prevalence of overweightness and obesity was observed in the inactive participants within this study. Reversing modern diet and lifestyle factors are continually portrayed within existing literature as solutions to this on-going problem.

5.2 Variables

5.2.1 **Effect of gender**

Fatness (BMI) and gender

Both males and females are increasing in body weight and this study found that no significant difference between the two genders exist. The incidence of overweightness or obesity was over 70% in male adults and over 60% in females; however their mean BMI values remained the same throughout the three survey years. Our prediction is that over the next ten years from 2007 to 2017 males will increase their mean BMI to 30 kg/m^2 and females to 29.5 kg/m^2 which has significant implications. The health impacts of such increases in body mass would include increased prevalence of cardiovascular disease, diabetes, stroke and a drop in physical functioning which may exacerbate the problem even further.

Physical activity and gender

The current study found that males are more active than females, with nearly double the rates of total physical activity compared to females (males 1043, while females 657 minutes of total activity in 2007 per week). Similarly, men were higher within all variables of physical activity, particularly the increased incidence of male moderate and vigorous physical activity compared to females (males 784 and females 479 mean minutes per week). This confirmed findings in previous research that found men were more likely to engage in moderate and vigorous-intensity physical activity compared to women (Ball, 2003; Azevedo et al., 2007).

The literature reveals several possible explanations for the higher levels of physical activity performed by men. Firstly, it has been argued that while men practice physical activity because they enjoy it, women seem to practice it with the goal of either improvement of health or aesthetics (Azevedo et al., 2007). As the more you enjoy something, the more likely you will be to pursue it, the differing motives for activity may affect participation. Secondly, there are different societal expectations for men and women regarding physical activity. Historically, physical activity was expected of men but not thought appropriate for women (Best, 2010), therefore perhaps men still see themselves as being active.

Body weight, inactivity and gender

The results indicated that the incidence of overweightness and obesity increase with inactivity. Seventy nine per cent of males (and 66% of females) within the overweight or obese BMI category were inactive. In addition, the proportion of those inactive and overweight or obese is increasing overtime (9% increase for males and 6% for females from 2003 to the 2007 data). It is clear that once participants are overweight or obese it is much less likely for them to be physically active. This may be due to the increased difficulty such individuals have when exercising or that the increased fatness is due to the reduced physical activity. Although as a frequency total males and females had a similar percentage of obesity, males had a higher frequency of overweightness (12%), and also a substantially greater total number of physical activity minutes per week and lower rates of physical inactivity than females. The most likely explanation for males being more overweight ,while also being the more active gender may be a result of their diet with greater calorie consumption in than energy expenditure out . The other explanation may be that males have a greater muscle mass and this greater quantity of muscle is showing up as fat within BMI measures.

5.2.2 Effect of age

Fatness (BMI) and age

A wealth of evidence suggests that weight increases are occurring in the younger populations (WHO, 2003; Onis & Blossner, 2000 cited in Ofei 2005; Turnbull, Barry, Wickens & Crane, 2004).This study however, found that the youngest group within this sample had one of the lowest changes in BMI over the ten year period and the lowest mean BMI compared to all other age groups. This finding could potentially be explained through the high correlation found between this group's low BMI and their high levels of vigorous intensity physical activity. Improved physical functioning within this group also aids their ability to be active and participate in a range of physical pursuits. On the other hand obesity and fat deposition takes time to occur and may only start to manifest in the older age groups.

The second lowest mean BMI value was recorded within the oldest age group of the 75 and older participants. The 75 years and over participants BMI were up to 1 to 2kg/m^2 lower than participants from 25-64 years of age. Two explanations are presented in the literature to explain this finding. Firstly, the reduced obesity among these older subjects may reflect lesser adoption of modern diet and lifestyle. The purchasing of energy dense fast foods over traditional home cooked meals may be less applicable to older participants. Also increased technology within modern lifestyle may not be adopted within these participants, increasing active pursuits and lowering BMI. Secondly, increased survival of leaner subjects, and/or weight loss due to concurrent illness, could equally be a factor (Hodge, Dowse & Zimmet, 1996).

Within those aged between 45-65 years of age, higher levels of BMI were recorded (mean BMI around 29kg/m^2). Gradual increases around middle age and onwards have also been documented previously (Metcalf, 2000). The adoption of modern diet and lifestyle may be more readily accepted within these populations. The changing biological functions, particularly within women as a result of menopause, are one suggested reason behind increased weight over these older age groups. Others have found that both menopausal and aging effects independently influence the increments of general obesity and the tendency of central body fat accumulation in women after menopause (Chang et al., 2000). It may also be that discretionary income increases at this age group and along with a decrease of competitive sport, pressure at work and family commitments, individuals in this age group are able to purchase more luxury items and become less physically active.

Physical activity and age

As we all know, as we age, our physical activity levels decline. The results from this study confirm this as the youngest sample population of 18-24 year olds had a total mean increase in physical activity of 86 minutes, while the oldest sample population had a decrease of 24 minutes over the survey years. However, this study also found that the younger populations are actually increasing their activity more than the older groups.

For all groups, the greatest increases were seen within the brisk walking minutes category. The greatest decreases within moderate intensity physical activity were seen within older groups and the greatest decreases within vigorous intensity physical activity were seen within younger groups. The already low levels of higher intensity physical activity within older age groups are likely to be the reason behind the small change in vigorous activity. It has been hypothesised that the decreases in vigorous activity in younger populations are a result of more people being engaged in sedentary work than before, spending more time in traffic queues and leisure time now incorporates a larger proportion of television, computer and video game viewing and less time spent on physical activity (Grantmakers of Health, 2001 cited in Skidmore & Yarnell, 2004). The increases in technological leisure time activities may become the leading cause of physical inactivity in younger populations. Through the popularity of television viewing, online gaming and other technology based pastimes, less leisure-time is available for physically active pursuits.

Mummery et al. (2007) found a significant association between age group and inactivity, with members of the 80 year old and over group being significantly more likely to be inactive than their younger counterparts. This research found a decrease in physical activity with age, particularly for participants from 65 years and older. Rapid declines within the 75+ age group were seen with under half the total weekly minutes of all activity compared to other groups. Adult physical activity is reported to be mainly achieved through occupational activity, active transport, caregiving responsibilities and leisure pursuits (Livingstone et al., 2003). Therefore, those in the 65 and over age groups may be experiencing these significant declines in activity as a result of changing lifestyles during retirement. Additionally physical functioning, disease and illness all negatively impact one's ability to perform physical activity with age.

Body weight, inactivity and age

The incidence of overweight and obesity of inactive participants is greatest over middle-to-older age, (except for those 75+ and above). The greater incidence begins around 45 and peaks at 65-74 years of age with an 85.9% occurrence. The 18-24 year olds are lowest with only 49.7% overweight and obese being inactive. There was compelling evidence within the literature that showed that as we age our activity levels decrease and with decreased activity often weight gains increase. Greater home and work responsibilities, along with a greater occurrence of sedentary occupations may be the main reasons as to why the 45 to 65 year olds showed the greatest incidence of being inactive and overweight.

5.2.3 Effect of ethnicity

Fatness (BMI) and ethnicity

The findings in this study confirm those found in a variety of studies (Wang &Beydoun, 2007; Howard, 1986; Nauru, 1992; Langdon, 1975 cited in Hodge, Dowse & Zimmet, 1996; McLaren, 2007) that ethnic minority groups often show some of the highest obesity rates. In this study, the ethnic groups of Pacific Islanders and Maori were found to have the highest rates of recorded overweightness and obesity. For Pacific Islanders, 94% of males and 90% of females were found to be overweight or obese with a mean BMI of 33kg/m^2 and for Maori, 84% of males and 75% of females were found to be overweight or obese with a mean BMI of 30kg/m^2.

An explanation for the higher rates in body mass by ethnicity is offered by both Barrow, (1967), and van Dijk, (1991 cited in Metcalf et al. 2002), who argue that culturally a higher body mass is accepted and reported as desirable within the Pacific Island and Maori cultures. It has been well documented that Pacific Island people find a fuller figured body more attractive (Barrow, 1967; van Dijk, 1991 cited in Metcalf et al., 2002). New Zealand has experienced high rates of immigration from the Pacific Islands, bringing traditional Island beliefs and values into modern multicultural living which mean that these cultural standards are likely to exist here.

Maori and Pacific Islanders tend to be over-represented in the lower socio-economic segment of the population (Centre for Public Health research, 2002). Like many lower socio-economic groups, Maori and Pacific Islanders live in conditions that make time for participation in physical activity difficult. This is compounded by the popularity of fast food, which is attractive due to its low cost and easy availability. Such factors will undoubtedly result in higher energy consumption and lower energy expenditure leading to increased body fat levels.

The large increase seen within Asian males over the ten year period with a 21.5% increase in the percentage of participants overweight or obese will similarly increase health problems and increase the burden on health funding for these individuals. The suggested reason for the large increase in body mass of the Asian male participants could include the adoption of a more westernised diet, (as there were significant increases in their physical activity levels which seems counterintuitive). Previous studies have shown that given the same level of BMI, Chinese and many other Asian groups have a higher percentage of body fat than do Caucasian (Deurenberg et al., 1998; Deurenberg et al., 2000 cited in Pan et al., 2004). These higher rates of body fatness may be a result of a lifestyle associated with low physical activity and a low-fibre diet (Kromhout et al., 2001 cited in Pan et al., 2004).

The negative health consequences that continue to rise with significant population increases in body weight are a major problem. The health problems that are associated with obesity, such as type 2 diabetes mellitus and coronary heart disease are more prevalent in New Zealand Maori and Pacific Island adults than Europeans (Bathgate et al., 1994, Simmons et al., 1994, Bell et al., 1996 cited in Rush et al., 2003), possibly due to the higher rates of body mass seen within these ethnic groups and a result of diet and lifestyle. As over 90% of Pacific Island participants and over 75% of Maori participants were overweight or obese, the factors contributing to these statistics gain importance, as physical functioning, absence of disease and an increased life expectancy could be achieved through greater physical activity expenditure, over an energy dense diet.

Physical activity and ethnicity

The findings in this study confirm those found by Ross & Hamlin, (2007) that Maori are at least as active as European New Zealanders. The total activity per week was reported to be 1013 minutes for Maori and 783 minutes for Pacific Islanders, compared to 794 minutes for Europeans.

The suggested reason for these high rates of activity within these ethnic minority groups is that the lower the socioeconomic level the lower the rate of inactivity (Azevedo et al., 2007). This is relevant for Maori, as Maori often fall within the lower socioeconomic groups. As will be discussed in more detail later, the greater activity levels of Maori are believed to be due to the considerable amount of activities that are performed during work, commuting and household chores for people with a very low income (Azevedo et al., 2007). Active work, active social activities and greater energy expenditure through active transport and housework may all be suggested reasons for the considerably higher levels of physical activity seen within Maori participants.

The largest ethnic minority segment within New Zealand: the Asian population, also produced confounding results. This population, who traditionally produce lower statistics in terms of physical activity participation, produced the most statistically significant increases in physical activity over the majority of the physical activity intensities. However, despite these significant increases, this ethnic group are still producing the lowest number of mean total physical activity minutes over all other ethnic groups. In Canada, South Asian men and women were found to be among the least active ethnic groups and in the United Kingdom it has been shown that physical activity is lower in all South Asian groups compared to the general population (Fischbacher, Hunt & Alexander, 2004 cited in Bryan et al., 2006). The lower adoption of a western lifestyle may be a contributing factor, along with historical patterns of lower intensity physical activity. Such popular pursuits as Tai Chi, although beneficial for health, is not at an intensity of activity to prevent weight gain living in a location with an increasingly energy dense western diet. Further research into the explanations for these findings would be beneficial.

Body weight, inactivity and ethnicity

Pacific Islanders are more commonly in the overweight or obese categories if inactive with a 94% incidence, followed by 84% for Maori. These results are not surprising given their high prevalence of overweight and obesity in the first place. The 51% decrease between 2003 and 2007 within the Asian obese category is highly likely to be a result of their 236 minute mean increase in total physical activity per week. This was the only group to have a statistically significant mean increase in total activity. Oversampling within this ethnic group may be another contributing factor.

5.2.4 Effect of deprivation

Fatness (BMI) and deprivation

McLaren's (2007) argument that the obesity burden is said to be falling on people of lower socio-economic status in middle-income countries is consistent with this research, with the greatest increase in BMI seen within the most deprived participants (4.4kg/m^2). The more deprived are suggested to have greater increases in weight due to the easy availability and low cost of fatty foods (McLaren, 2007). A positive association between BMI and socioeconomic deprivation was observed within the New Zealand research by Utter et al. (2010) in Pacific, Maori and European people, and consistent with the findings within this study.

Increases in body mass were seen over the ten year period within every subgroup measured, except the second most deprived group. Those in the second most deprived group recorded a 1.5kg/m^2 decrease. Although an overall decrease was observed within this group, their mean BMI is still above all other groups that are 'less deprived' within the sample population. One of the possible reasons for this could be a result of the large 2003 mean BMI recorded (29.6kg/m^2) during that dataset year and the significantly lower mean (26kg/m^2) recorded for the most deprived. Changing dietary choices and physical activity patterns may be responsible for these values, along with oversampling, and socially desirable responses.

The least deprived recorded the lowest mean levels of recorded BMI values. A combination of higher social strata in developed countries being more likely to value and pursue thinness is one explanation for these findings (McLaren & Kuh, 2004 cited in McLaren, 2007). Along with individuals within the least deprived segments of society earning an increased income allowing access to healthier foods are suggested reasons behind these results. Education allows such participants the knowledge of what foods to eat. An increased income also allows for greater access to health resources.

Physical activity and deprivation

Several theorists have examined the links between socioeconomic status and physical activity (Lindstorm, Hanson & Ostergren, 2001; Azevedo et al., 2007; Guthold et al., 2008). The results from this study were consistent with research suggesting that the lower the socioeconomic level the higher the rate of activity (see for example – Azevedo et al., 2007). One explanation provided for this correlation is the connection between manual labour and low socio-economic status. Lower socio-economic status is often associated with increased manual labour at work owing to lower levels of education. Additionally, lower socio-economic groups are likely to lack the funds to own personal transport thereby requiring them to take public transport and increasing their incidental activity levels.

In contrast to those in lower socio-economic groups, studies have found the least deprived to be less active during work time due to having jobs that do not require manual labour. They were also found to have more disposable income for sedentary technological pursuits. While little is known within this study as to the occupational, household and transportation behaviours of the participants, >80% of men and >90% of women are now reported to be engaged in sedentary occupations (Livingstone et al., 2003). Sedentary, office jobs are often held by professionals rather than by lower classes, with lower classes argued to be more involved in manual labour. Assuming these figures are similar in New Zealand, these trends would likely affect activity levels in this country. As discussed in the previous section, Maori and Pacific Islanders, known to generally fall under a lower socio-economic status, recorded the highest rates of activity further confirming these hypotheses.

Additionally, time pressure is argued to leave many thinking that they cannot afford the time required for active transport to work and school, diminishing the opportunities for incidental physical activity (Banwell et al., 2008). Higher socio-economic groups have been found to spend more time participating in recreation, but spend more time working because they pay people to clean their houses and the additional time spent working reduces their time available for physical activity (Crespo et al., 2000). Consequently, their overall physical activity levels tend to be lower.

5.2.5 **Effect of location**

Fatness (BMI) and location

While statistically significant changes in body mass by location were observed through the increases in weight within rural participants, the two locations produced almost identical mean values over the last recorded survey year. Physical activity changes discussed below are suggested to be the contributing factors for these results.

Environmental and socio-cultural factors also affect weight in relation to location (Corsica & Perri, 2003). Environmental factors encompass anything in the environment that makes us more likely to eat too much or exercise too little (Health Harvard Publications, 2013) and can differ by location. While socio-cultural factors concerned with weight are seen as a positive thing in some cultures where food is scarce and some countries and societies weight and especially obesity is not only seen as something that is undesirable, but also a threat to the health of an individual. Also the types of food that are consumed in different cultures and societies can affect the health and wellbeing of an individual affecting weight in relation to location (ACS, 2013). People of the same ethnic groups but in differing locations can also have twice the influence of obesity in different lifestyles (Corsica & Perri, 2003) as a result of the differing environmental and socio-cultural factors of the two locations. This may well be the case for Asian and Pacific Island participant's that have immigrated to New Zealand. Diet and physical activity influenced by a western culture of mostly fast food and inactive leisure time activities in New Zealand may result in weight and activity statistics differing from individuals in indigenous locations.

Physical activity and location

Geographical location is also reported to have an influence on our physical activity. Rural participants have been found to be more active, with the effects of modernization in urban areas clearly evident in rural-urban comparisons and migrant studies (Hodgkin, Hamlin, Ross & Peters, 2010). Those living in urban areas are more likely to be inactive compared to those living in rural areas (Guthold et al., 2008).

However, within rural participant's, technology has reduced physical exertion within most work activities. Technology has allowed for less physically demanding work, and reduced energy expenditure. Although rural participants are more active than their urban counterparts (383 more minutes of total physical activity per week) their total activity levels per week are decreasing (-69 minutes). Greater access to leisure-time physically active pursuits may counteract the potential decreasing levels of work related physical exertion.

5.3 Limitations

5.3.1 The sample

The predetermined nature of the survey design and data collection did not allow any choice in the range and type of questions asked and the measures used. The sample, as discussed within the methods section, has some flaws. The over representation of females and ethnic minorities are unrepresentative of the New Zealand population, however, they do provide a greater scope and wealth of information on the areas of the population that were identified as needing the greatest attention now and into the future.

The lack of a third national data set incorporating physical activity data makes comparisons over a longer time period difficult, as the current four year physical activity datasets are not large. This was one of the greatest limitations; however, with no further appropriate Ministry of Health data being released within New Zealand since the used 2006/07 information, no other option was available at the time of undertaking this thesis.

5.3.2 **The methods**

While anthropometry is the most universally applicable, inexpensive and non-invasive method available to assess the size, proportions and composition of the human body (MOHi, 2008), the use of BMI as a measure of body mass values has received varied feedback.

Statistically the limitation of using means and generating significance from these means incurs the limitation of inaccuracies with (p) values. The upper and lower values within all of the categories need to be taken into consideration especially with some ranges having a negative value which alters the (p) significance of the change. However, this limitation was overcome with the inclusion of the magnitude-based inferences modelling.

There is a wealth of literature that describes the potential inaccuracies that can occur through the use of questionnaires and other self-reported collection tools. Many report of the overestimation of activity within the International Physical Activity Questionnaire (Hallal et al., 2003; Ekelund et al., 2006; Rzewnicki et al., 2003 cited in Guthold et al., 2008) and the underestimation of inactivity (Guthold et al., 2008). Suggested possible social pressure for males to over-report their physical activity levels more so than women, is one explanation given as to why women have higher associations with lower activity and higher BMI (Ball, 2003), as socially desirable responses make reliability and validity inconsistent (Livingstone et al., 2003).

Despite this, this method of data collection provided a large sample size and gave essential comparable data to research. Questionnaires are described as the most useful for assessing patterns, frequency, type and context of physical activity (Livingstone et al., 2003). While questionnaires can give a good indication of different types of activity, they do not have a direct relationship to the energy costs of that activity for that individual (Kriska et al., 1990; Pate et al., 1996; Going et al., 1999 cited in Rush, et al., 2003). As discussed within the literature the actual reporting of physical activity may be better realised through events rather than weekly patterns. Total daily recall of activity may provide greater reliability, but at the same time, it has the potential to bias results due to socially acceptable performance ideas and the individual possibly performing more activities when they know that it is being recorded. Greater research within occupational, home and transportation activities along with physical activity pursuits will provide a clearer picture of activity patterns. Possible investigations behind the motivations of moderate and vigorous intensity activity in particular, could produce interesting findings to aid in a greater understanding of physical activity behaviour.

It has been reported that minority groups more often choose extreme response categories when reporting judgements on rating scales. Subjective assessment of intensity may be problematic because the perception of intensity varies among cultural or racial groups and may be confused with stress levels and level of enjoyment of the activity and thereby biasing reporting (Tortolero et al., 1999 cited in Bryan et al., 2006). Therefore research into the methods of physical activity interpretation and recall is warranted in the future, along with global standards for greater comparability of research.

Lastly, greater clarification in relation to ethnic identification is warranted globally. Particularly in terms of Asian representation. Confusing use of grouping a number of different ethnic cultures together within past literature makes comparisons hard and interpretations of what is meant by 'Asian' among differing authors a research limitation.

5.4 Implications of the research

The main purpose of this research project was aimed at improving knowledge around obesity and physical activity levels of New Zealand adults and the relationship between the two. The results found within the findings of this research has provided greater insight into the levels of activity and the body mass changes of New Zealand adults.

The results from this research has shown us that not everyone is gaining weight and subsequent waist circumference and not everyone is becoming inactive and reducing their activity levels either. Such results allow us to investigate in more detail which subgroups within the population require the most attention. These results clearly show the impact of an inactive lifestyle with inactive people being more likely to be represented in the higher levels of BMI and obesity.

One of the major implications of this research will be the negative light shed on ethnic minorities within New Zealand, especially in terms of body size. This could potentially identify at risk groups in a very public setting. The need for further education in this area is warranted in how to effectively create awareness of the issues surrounding increasing body weight and adiposity while being culturally sensitive.

From the research presented there was an obvious statistically significant increase in the physical activity of Asian participants. While their mean BMI values continue to increase, obesity within inactive participants showed substantial decreases. Greater research within Asian populations both born and immigrated to New Zealand is needed to understand why their activity levels are increasing so significantly. Since the increases are so significant what other lifestyle changes are occurring within their lives to produce these body mass increases. A significant part of the change may be due to oversampling procedures, therefore more work in this area is required.

The answers to these problems are simple, but change is difficult. Physical activity needs to increase and with that a move from walking into more moderate and vigorous active pursuits. Active transport can assist with this by shifting to more vigorous transport options and away from motorised transportation. It would also be beneficial for more green spaces to be developed and used to allow for more leisure time activities. The time spent on passive technological activities at home and at work needs to decrease and more time spent being active. The creation of active technology options such as Kinect sports (interactive games where body movements are tracked and used instead of handheld controllers) is helping to make popular sedentary activities more active, and may be viable options into the future.

Chapter 6

Conclusion

The physical, psychological and financial consequences of obesity and physical inactivity have been well recognised and the benefits of such practices as a healthy body mass and being physically active have been established. With a global obesity epidemic and patterns of inactive behaviour, New Zealand research relating to the trends and changes in body mass values and activity levels of New Zealand adults is vital. The significance of such research is amplified by a distinctive lack of studies within New Zealand, specifically examining the body mass values and physical activity levels of New Zealand adults over a longer time period and analysing changes within selected subgroups.

As a result of the lack of research surrounding the weight and activity levels of New Zealand adults, this research has determined an obvious mean increase in BMI and a rise in the proportion of individuals within overweight and obese categories. However, the distributional curve suggests that not everyone is getting bigger and gaining weight. There is a proportion of the population that remains at a healthy weight. However there are also those who were already overweight and obese who continue to get bigger. Weight management intervention needs to target these groups along with the middle aged, ethnic minorities and the most deprived within our population. Physical activity intervention should specifically target females, older adults, Asian ethnicities and urban participants.

Overweightness and obesity is a major problem in New Zealand and the decreasing levels of moderate and vigorous intensity physical activity is contributing to this problem. With the mean BMI of male and female New Zealanders increasing towards the obese category, we need to be more active as a nation. That activity needs to occur at greater rates of intensity and the increases in walking need to be achieved within all groups. Significant action needs to occur within our indigenous ethnic minorities of Maori and Pacific Islanders. Targeted physical activity interventions along with nutritional education may substantially reduce these figures; however on-going support and policy change is required.

With an aging population and increasing rates of obesity and low activity, intervention is crucial to curb this trend for longevity and the prevention of morbidity. Continual weight gain from middle-age and beyond leads to lower levels of activity. This also needs to be taken as a caution as those in the 65+ age group are also known to suffer from greater rates of disability and pain which in turn may restrict activity and increase weight. As modernisation, urbanisation and technology advance, the least deprived will require greater assistance in terms of physical activity access and urban participants will need to incorporate more active transport and lifestyles that are more active.

Potentially one of the greatest areas of future research will be to gain further information into the individuals that have managed to maintain a healthy weight within this increasing physically active toxic environment and for those that are overweight, further investigation of their diet and lifestyle may provide additional answers. The analysis of this national data assists in greater understanding of how and where body weight is increasing and the relationship of physical activity to our obesity problems. Further research into developing better survey and measurement tools is essential, as accurate measurement and analysis of these variables is crucial for future generations.

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Appendix A

Table 1 Survey questions asked within each survey by year and for physical activity

1997	2002/03	2006/07
Data not available	**133** During the last 7 days, on how many days did you walk at a brisk pace- a brisk pace at which you are breathing harder than normal? This includes walking at work or school, while travelling from place to place, at home, and at activities that you did solely for recreation, sport, exercise or leisure. Think only about brisk walking done for at least 10 minutes at a time **___ days per week ____none** **134**How much time did you typically spend walking at a brisk pace and each of those days? **___hours _____ minutes**	**3.12** During the last 7 days, on how many days did you walk at a brisk pace- a brisk pace at which you are breathing harder than normal? This includes walking at work, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure. Think only about walking done for at least 10 minutes at a time **_____ days per week** **3.13** How much time did you typically spend walking at a brisk pace and each of those days? **___hours _____ minutes**
Data not available	**135** During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, doubles tennis or other activities like those on card 135? Do not include walking of any kind. Think only about those physical activities done for at least 10 minutes at a time **____ days per week ____ none** **136** how much time did you typically spend on each of those days doing moderate physical activities? **______ hours_____ minutes**	**3.14** During the last 7 days, on how many days did you do moderate physical activities? 'Moderate' activities make you breath harder than normal, but only a little – like carrying light loads, bicycling at a regular pace, or other activities like those on card 3.14. do not include walking of any kind. Think only about those physical activities done for at least 10 minutes at a time. Record number of days or circle appropriate answer. **____ days per week** **3.15** How much time did you typically spend on each of those days doing moderate physical activities? **___ hours_____ minutes**
Data not available	**137** during the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, fast bicycling, or other activities like those shown on card 137 Think about only those physical activities done for at least 10 minutes at a time. **___days per week ___ none** **138** How much time did you typically spend on each of those days doing vigorous physical activities? **____ hours____ minutes**	**3.16** during the last 7 days, on how many days did you do vigorous physical activities? 'Vigorous' activities make you breathe a lot harder than normal (huff and puff) – like heavy lifting, digging, aerobics, fast bicycling, or other activities like those shown on card 3.16 Think about only those physical activities done for at least 10 minutes at a time. **___days per week** **3.17** How much time did you typically spend on each of those days doing vigorous physical activities? **____ hours____ minutes**
Data not available	**139** thinking about all your activities – vigorous or moderate including brisk walking – on how many of the last 7 days were you active for? "active" means doing 15 minutes or more vigorous activity or 30 minutes or more of moderate activity or brisk walking **___ days per week____ none**	**3.18** thinking about all your activities over the last 7 days (including brisk walking), on how many days did you engage in: • At least 30 minutes of moderate activity (include brisk walking) that made you breathe a little harder than normal, OR • At least 15 minutes of vigorous activity that made you a lot harder than normal (huff and puff)? **_____days per week**

Appendix B

Table 2 Survey questions asked within each survey by year for body mass values

1996/97	2002/2003	2006/07
Clinical measures Pregnancy Blood pressure BP Pulse	I would like to take a height, weight and waist measurement. (Ask respondent to remove shoes and any heavy outer clothing. Weigh on hard floor preferable.) ___pregnant ___refused	Yes respondent is pregnant skip this section. No. respondent is not pregnant [continue] Refused – skip section Not sure/ don't know- skip section
Height format 999.9 units cm First height measurement Second height measurement 0.5cm difference Third height reading	**Reading 1** Height [, , .]cm Weight [, , .]kg Waist [, , .]cm	**Reading 1** Height 000.0 cm Weight 000.0 kg Waist girth 000.0 cm
Weight format 999.9 units kg First weight reading Second weight reading If 0.5kg difference Third weight reading	**Reading 2** Height [, , .]cm Weight [, , .]kg Waist [, , .]cm	**Reading 2** Height 000.0 cm Weight 000.0 kg Waist girth 000.0 cm
First hip circumference measurement Second hip circumference reading Third hip circumference reading **First arm circumference** measurement Second arm circumference reading Third arm circumference reading **First waist circumference** measurement Second waist circumference reading Third waist circumference reading **All in 999.9 unit cm**	**Check for discrepancies –** height if more than 0.5cm, weight 0.5kg, waist 1cm difference between 1st and 2nd reading **Reading 3** Height [, , .]cm Weight [, , .]kg Waist [, , .]cm	Computer repeats prompts as above and automatically does calculation if 3rd reading is required – if more than 1% difference between first and second reading, a third reading is required **Reading 3** Height 000.0 cm Weight 000.0 kg Waist girth 000.0 cm
Also first, second, third • **Tricep skinfold measurement** • **Subscapular skinfold measurement** • **Elbow width measurement** 1.2kg clothing weight correction	Did respondent wear shoes? Was person wearing…? • Winter clothing • Very light summer-weight clothing • Clothing between light and winter Time of day 24 hour clock	Remove shoes and all heavy outer clothing so we can obtain accurate measurements.

Appendix C

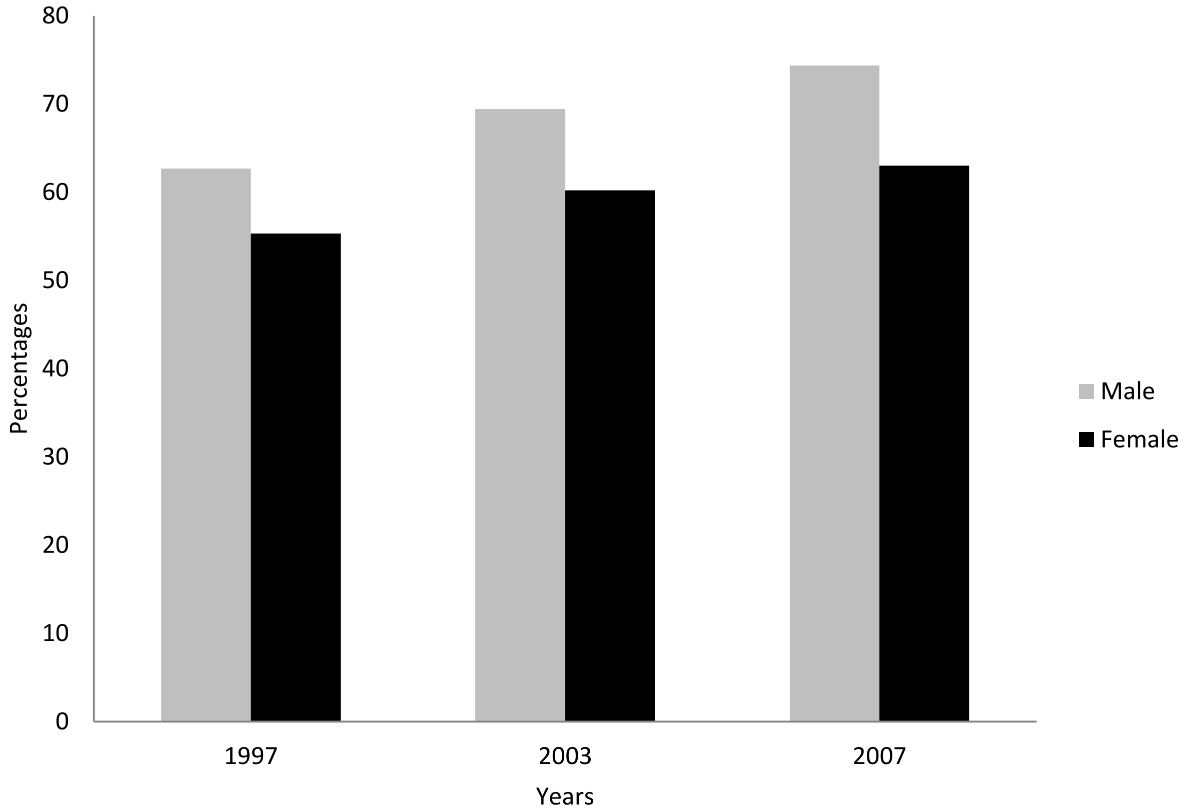

Figure1 Percentage of males and females overweight and obese by year

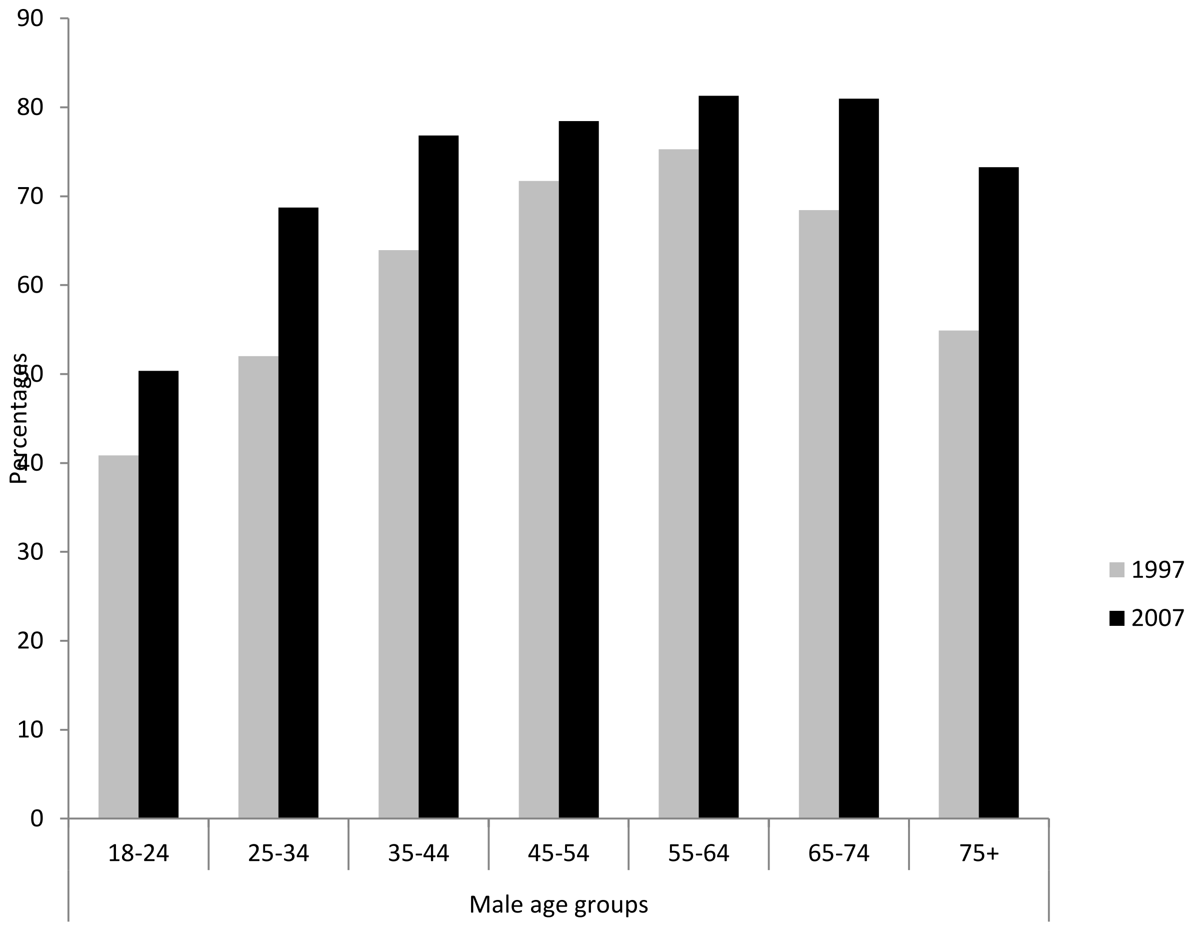

Figure 2 Percentage of males overweight and obese by age group and year.

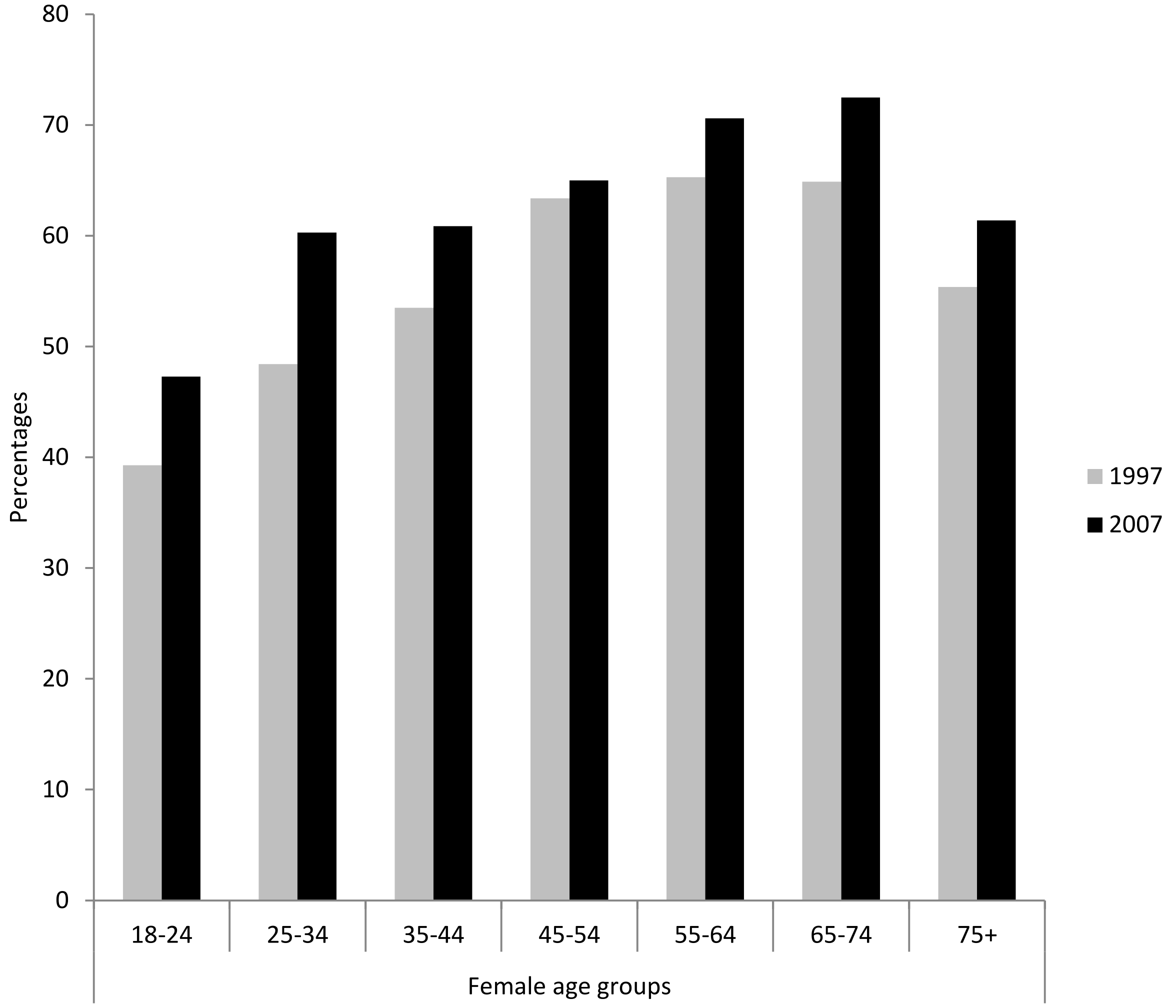

Figure 3 Percentage of females overweight and obese by age group and year

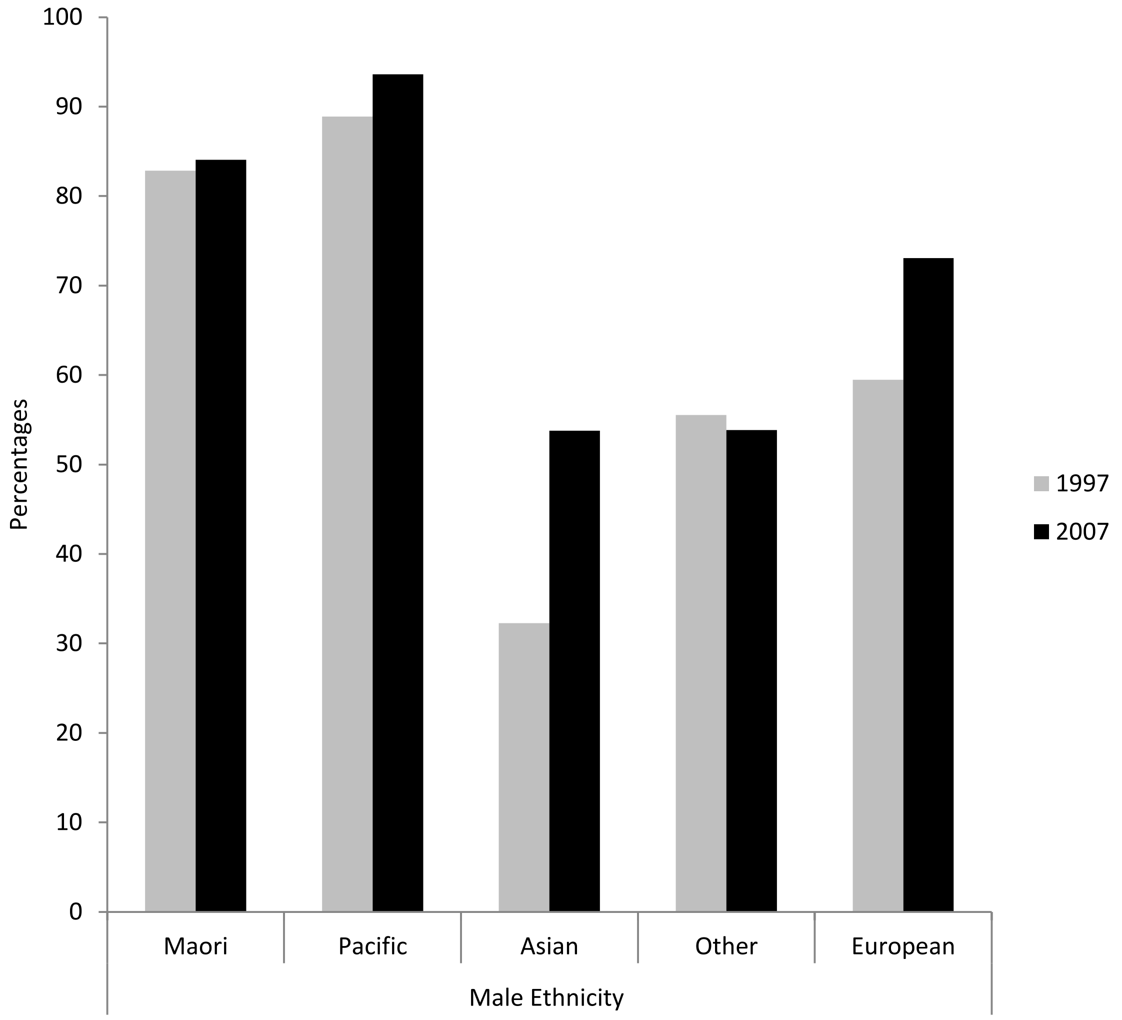

Figure 4 Percentage of males overweight and obese by ethnicity and year

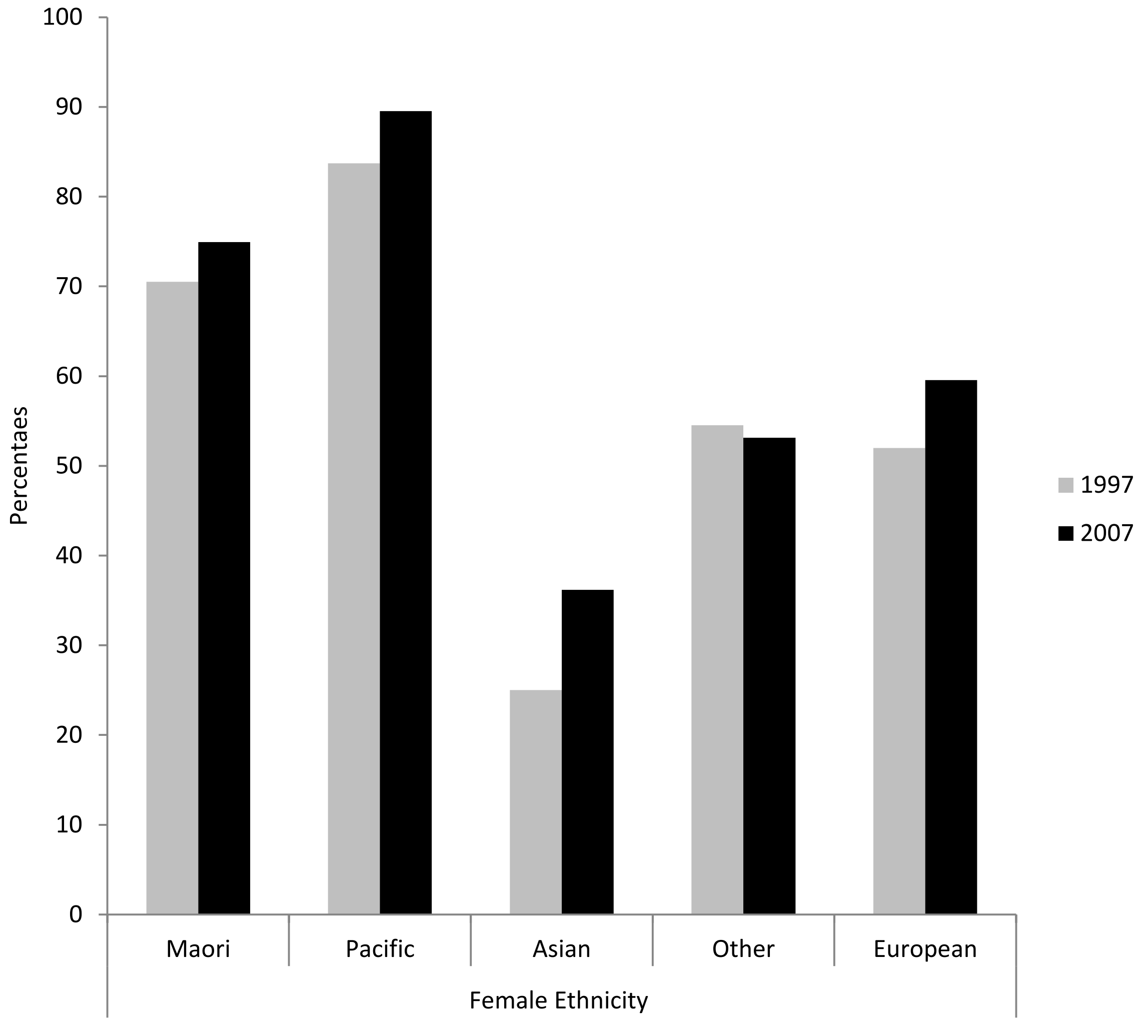

Figure 5 Percentage of females overweight and obese by ethnicity and year.

Appendix D

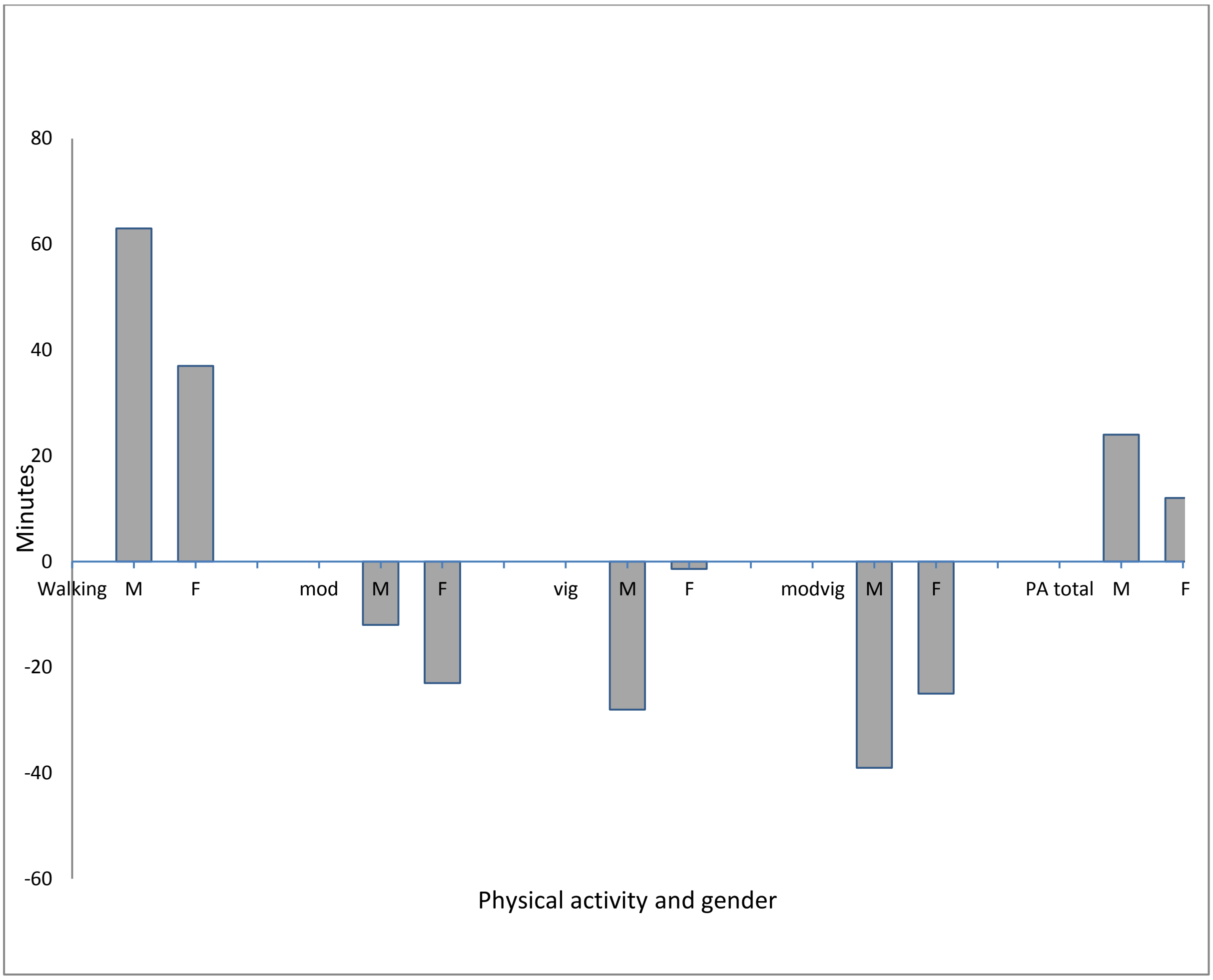

Figure 6 Mean change in physical activity minutes by gender

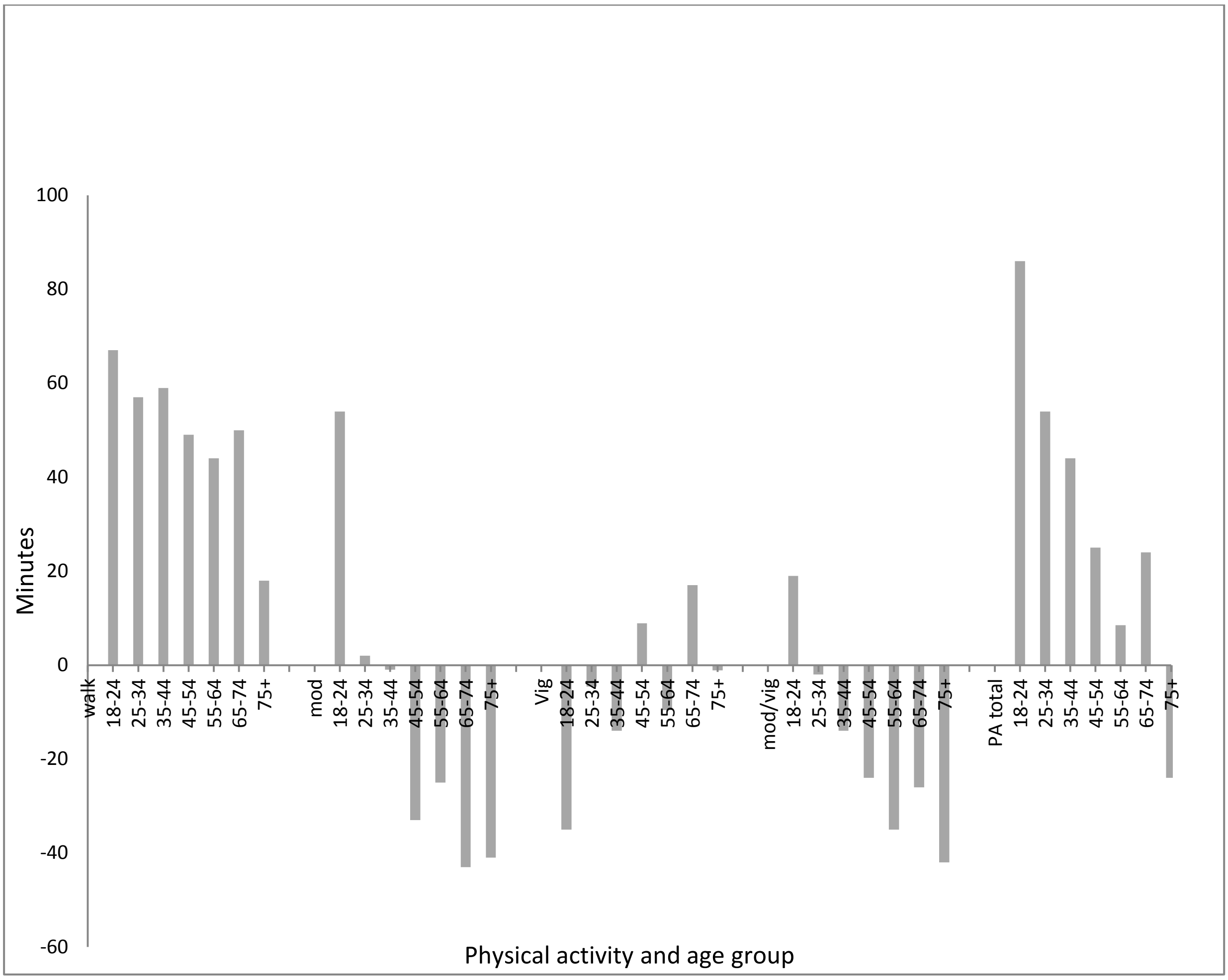

Figure 7 Mean change in physical activity minutes by age group

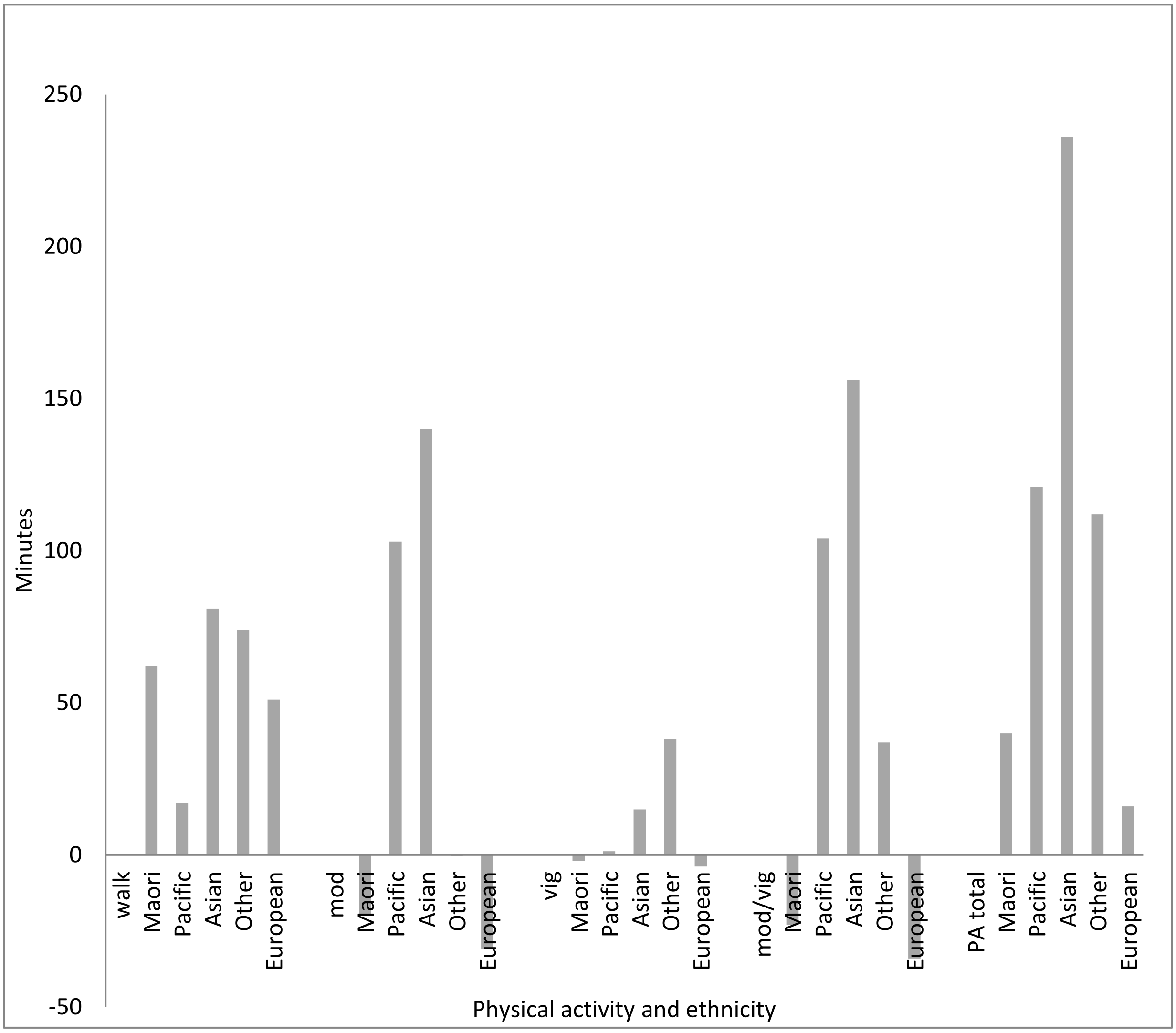

Figure 8 Mean change in physical activity minutes by ethnicity

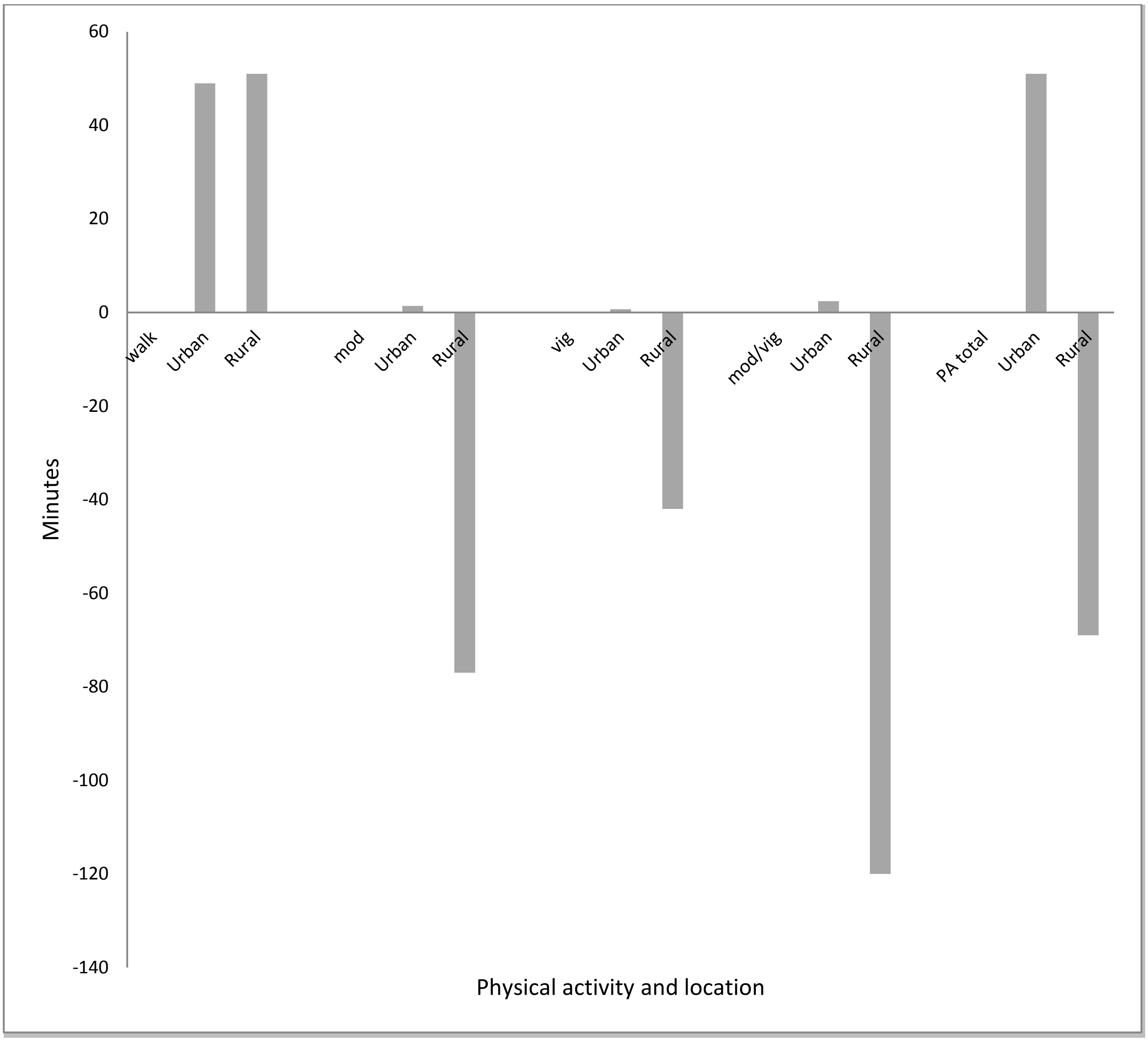

Figure 9 Mean change in physical activity minutes by location

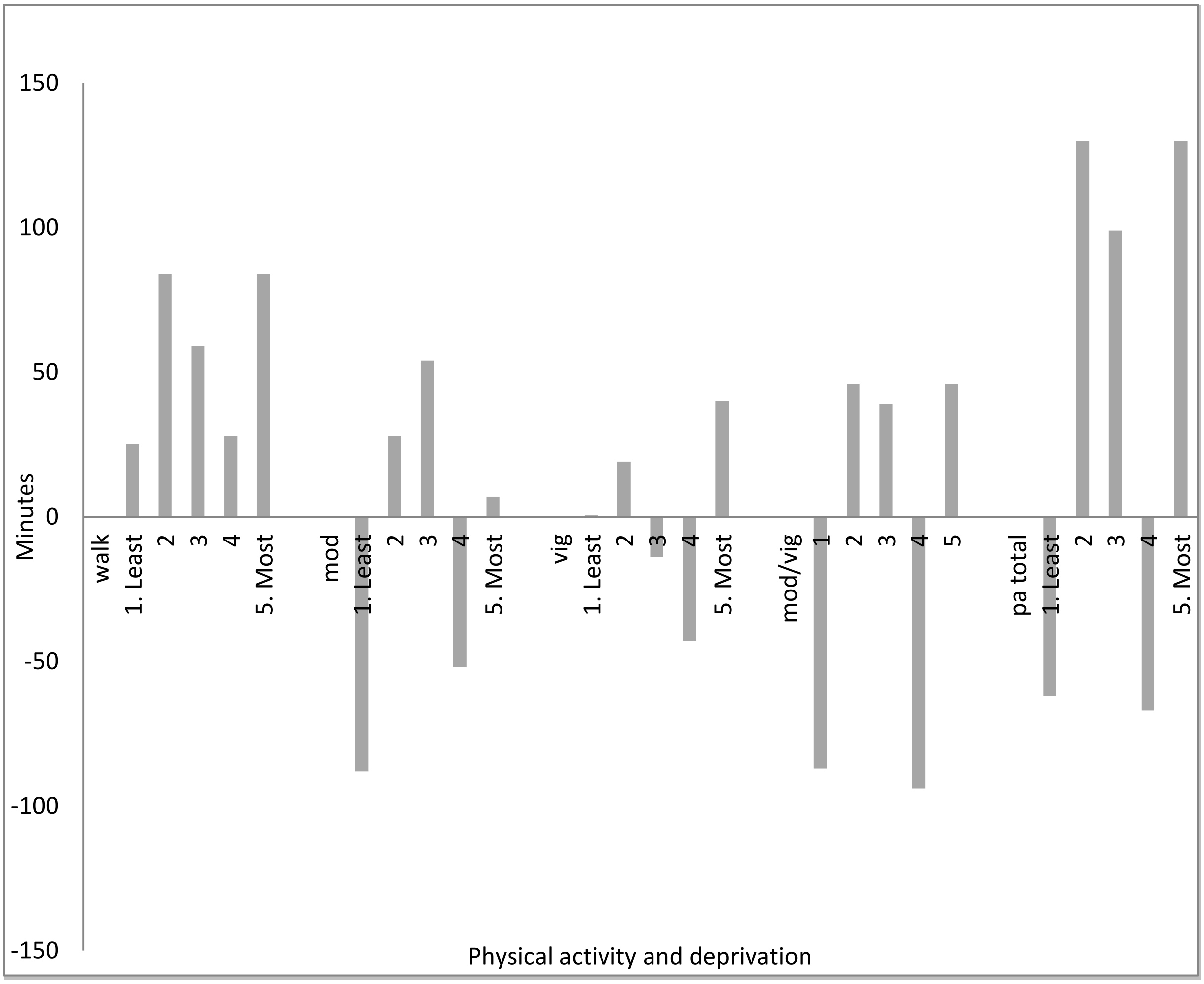

Figure 10 Mean change in physical activity minutes by deprivation